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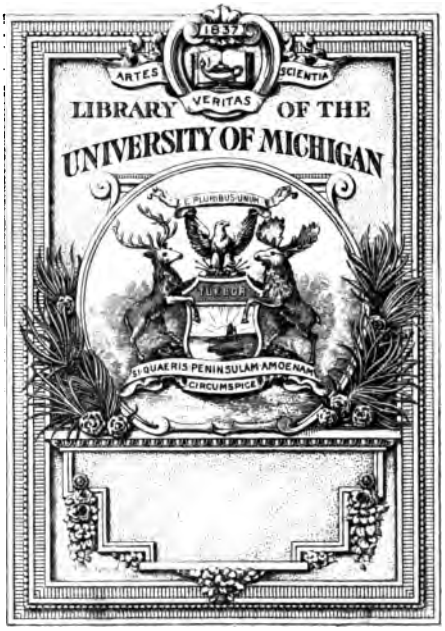
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OF THE

Royal Geological Society

OF

CORNWALL;

INSTITUTED FEBRUARY 11th, 1814.

VOLUME THE FIFTH.

"A knowledge of our subterranean wealth would be the means of furnishing greater opulence to the country, than the acquisition of the mines of Mexico and Peru."

President of the Board of Agriculture.

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The Author alone is responsible for the facts and opinions contained in this volume.

W. J. H.

I.—*On the Metalliferous Deposits of Cornwall and Devon.*

By WILLIAM JORY HENWOOD, F.G.S.,

MEMBER OF THE GEOLOGICAL SOCIETY OF FRANCE; HON. MEM. OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; SECRETARY OF THE SOCIETY AND CURATOR OF THE MUSEUM; H.M. ASSAY-MASTER OF TIN IN THE DUCHY OF CORNWALL.

(Read——1830 October 6th,—1831 October 7th,—1833 August 30th,—1834 October 10th,—1835 October 16th,—and 1836 September 2nd.)

WHETHER we look to the various modes in which the metalliferous deposits minister to the wants and conveniences of man, stimulate his industry, and multiply his resources; or speculate on them as the effects of powerful and yet unknown agencies;—they must appear among the most important and interesting objects of Geological inquiry.

But, although they may be studied in greater variety, complexity, and even extent in Cornwall and the adjacent parts of Devon, than in few, if in any, parts of the Globe; no full and detailed account of the phenomena they present in this district has hitherto been attempted. For Mr. Thomas's valuable contribution to our knowledge,*

* "Report on a Survey of the Mining District of Cornwall, from Chasewater to Camborne," with a Map and Sections. By Richard Thomas, Surveyor and Civil Engineer. 1819.

treats only of the localities to which his researches were avowedly directed, and confined. Mr. Carne's admirable memoir "on the relative age of the Veins of Cornwall,"* although embracing particulars of the greatest importance on other branches of their Geology; is principally confined to that investigation; whilst his second paper "on the Mineral productions and the Geology of the Parish of St. Just,"† treats of that district alone. Whilst the able and enlightened publications of my friend Dr. Boase, ‡ chiefly occupied with discussions of a wider range, and more comprehensive character, rapidly glance at this subject, as subordinate to his general design.

The deficiency here pointed out, it has been my object to supply; and for twelve years past, I have devoted my leisure to the task of collecting, by personal inspection and observation in every mining field in this district, all the particulars, which I thought, would throw light on the diversified modes in which the metalliferous deposits occur.

For two or three of the earlier years my progress was but slow; but in 1828, at the desire of Messrs. Robert Were Fox and Charles Fox, the investigations were prosecuted with greater activity; and, with some occasional interruptions, I have pursued them to the present time.

My circumstances would not admit of my incur-

* Cornwall Geo. Trans. II., p. 49. † Ibid. II., p. 290.

‡ "Contributions towards a knowledge of the Geology of Cornwall." Cornwall Geo. Trans. IV, p. 166, and "A treatise on Primary Geology." Longman & Co., London. 1834—8vo.

strike off on both sides in
Both granite and slate ar
lines of structure, nearly p
the *lode*, about S.E. and N.
of them nearly E. and W.

On the north-eastern sid
Polladan Cove,* an enormo
intervenes between the gran
at Pendeen the transition i
almost imperceptible, the g
quartzose, and the slate mo
approach: so that no other
in the mass which occurs at
bluish tinge on the side of the
greyer hue towards the granit

The junction may be also
the mines of Little Bounds, V
noweth, Botallack, and Levant

* In the processes of *dressing* the ores sm
escape with the water: at Polladan Cove pc
collected, and *dressed* for the tin-ore depo
flowing through the *dressing-floors* in Nancher
Wherever there is a

of my own pocket, has served to bring my undertaking to a termination.

The first part of my communication will necessarily consist of details, which I have endeavoured to arrange in such a manner as to show their connexion: whilst in the second, I shall attempt a general summary of the characteristics of the veins in this district.

To the particulars of each field or group I have prefixed a few general remarks indicative of its peculiarities, and shewing the relations which subsist between the veins of adjacent mines. These are, however, very brief, and they may be advantageously perused in connexion with the excellent publications of Mr. Thomas, Mr. Carne, Professor Sedgwick,* and Dr. Boase.†

In order to exhibit the various phenomena of each mine at one view, I have adopted a tabular arrangement of the details;‡ a mode which, I believe, has never before been pursued, and therefore some explanation of it is requisite.

The designations of the columns generally denote the various particulars which will be found in them. It is, however, not uncommon for the substance of the vein to pass into the contiguous rock by insen-

* Cambridge Phil. Soc., Trans. I, p. 89.

† Under the directions of the Board of Ordnance Mr. De la Beche has instituted most laborious and minute investigations of the Geology of this district, and the publication of the Map which he has coloured, and of the Memoir which is to accompany it, will greatly contribute to the elucidation of my subject.

‡ I am indebted to the kindness of Mr. R. W. Fox for many suggestions respecting it.

The intersections of the various veins by each other are very unintelligible, for although in a few instances the *heaves* appear regular, in the greater number it is far otherwise; and in many cases although the *lode* has continued rich in actual contact with the cross-vein, it has never been discovered on the other side. The *lodes* in Saint Just, as in other parts of Cornwall, are productive only at intervals, and where otherwise they are usually small, for poverty often accompanies a diminution of the size; whilst the containing rock which is very hard in every part of the district, often becomes still harder as the vein is impoverished. Both these circumstances contribute to the prevalence of this unfortunate ignorance of the phenomena accompanying the intersections, one by diminishing the incentive, the other by rendering the pursuit more difficult.

In every vein in the district the masses of metallic minerals have dipped from the granite; or if occurring in that rock, they have inclined towards the slate: in other words, the deeper portions of the ores have been furthest from the granite.

These dispositions of the rocks, directions of the veins, and distributions of the ores, directing many of the mining operations towards the sea, several of the mines are worked to some extent beneath the bed of the Atlantic, and the breaking of its waves is distinctly audible to the labourer whilst at his work.

In Little Bounds, Botallack* and Wheal Cock,

* Mr. Carne, Cornwall Geo. Trans., II. p. 339.

left, and *R.* for right hand, are therefore perhaps sufficiently explicit.

The directions of veins being so very different, they of course intersect at almost every angle, and as the portions are rediscovered either on the side of the *greater* angle, *(Pl. I. Fig.* 1.*)* or of the *smaller*, *(Pl. I. Fig.* 2.*)* I employ the letters *G.A.* to denote the one, and *S.A.* the other; mentioning also, where known, the distances between the parts.

The provincialisms employed in Cornwall, have by long and extensive adoption become almost a part of the mining vocabulary of the Kingdom, I therefore use them as synonymous.*

Collections of rocks and minerals illustrative of the various deposits have been placed in the Museums of the Jardin des Plantes, Paris; the Geological Society of London; the Yorkshire Philosophical Society; the Plymouth Institution; the Royal Institution of Cornwall, and of this Society.

As it is only from a careful study of particulars, that we can hope to ascend to generals, I proceed to them in some (I hope not irksome) detail; and

---

* The *rocks* whatever may be their characters are denominated *the Country*.

All metalliferous veins	*Lodes.*
All veins not metalliferous, and in direction subtending considerable angles to those which are productive	*Cross-courses.*
Horizontal galleries if excavated in metalliferous veins	Levels.
——— not in metalliferous veins	Cross-cuts.
Pits open to the surface	Shafts.
— not open to the surface, but extending on the dip of a vein from one gallery to another	Winzes.
All excavations horizontally	Driving.
——— downward	Sinking.
——— upward	Rising.

than once doubting the protection of our rocky shield we* retreated in affright; and it was only after repeated trials that we had confidence to pursue our investigations.

The quantity of water throughout the district is extremely small, and notwithstanding it is salt in all the mines which are worked beneath the sea, it is not much, if at all, more abundant in them than in those further inland: whilst that drawn out of the mines worked in granite, is so pure as to be fit for domestic uses.†

The mineralogical riches of Saint Just have been so ably described by Mr. Carne,‡ that a very brief enumeration of some of the principal products, and of a few of the most interesting localities will be sufficient for my purpose. The most usual ore of copper is the vitreous, but copper pyrites and native copper are of frequent occurrence, and several of the salts and other ores of this metal have been often found; oxide of tin has been found in great abundance, and the sulphuret of tin has been detected at Botallack;§ bismuth and its sulphuret have been found in several mines; and many of the ores of iron, of cobalt, and some of uranium have been met with in the district; with traces of the ores of lead, zinc, antimony, and of some other metals. Of earthy minerals eisenkiesel occurs in many of the

* My companion was the late Capt. Trenear, of Levant.

† It is a novel and an interesting sight to see the women collected about the mines with their trays, procuring warm water from the steam-engines; they wash their linen on the spot, and spread it to dry on the neighbouring commons.

‡ Cornwall Geo. Trans., II. p. 290. § Dr. Boase, Ibid II. p. 384.

mines; garnets, axinite, epidote, apatite, and hornblende are common in Wheal Cock-cairn; actynolite, is abundant in Porth Just, the Narrow-point, and Caseley's-cairn; schorl is plentiful, but may be procured finely crystallized at Botallack-bunny;* arragonite, and pearl spar have been found at Levant in some abundance.

It has been already said that *Little Bounds Mine* is opened from the beach at Porth Just,† *Wheal Bellon* is worked on the steep side of the vale which terminates at Pornanvon,‡ *Wheal Cunning, Ballaswidden, Park-noweth, Spearn,* and *Boscaswell Downs,* are situated on plains which have a slight declivity seaward. All the other mines are near the sea, and the positions of several of the steam-engines are highly picturesque; that of the Crown's engine at *Botallack* has been long well known, and

---

* This is the locality of the oft-described *tin-floors;* they are connected with the *lodes,* and seem to be mere branches between them, with less inclination than is usual.

See also Mr. Hawkins, Cornwall Geo. Soc., Trans., II. p. 33. Mr. Carne, Ibid II. p. 326. Fournet, Etudes sur les dépots mètallifères—232.

† Some extensive beds of rounded stones from the size of a hazel nut to 2 or 3 feet in diameter, and from 15 to 20 feet above high-water mark occur in both these coves. The stones are in general granite, but a few pebbles of slate are found among them, the interstices being filled with decomposed granitic matter. The adit at Wheal Besan's lode in *Little Bounds Mine* has been *driven* for several fathoms through one of the beds, which is there from 60 to 70 feet in thickness.

See also Mr. Carne, Cornwall Geo. Trans., III. p. 229.

‡ In stead of the *pick and gad* (pick-axe and wedge) used in other districts, a bar of steel pointed like the *gad* (the *poker*) is employed on hard rocks, and a somewhat similarly pointed, but thinner bar, (the *picker*) on softer materials. The Saint Just miner, using the hammer with one hand, and the *borer* with the other, prepares a hole for the reception of gunpowder without assistance; in other districts it is usual for one person to hold the *borer,* whilst it is struck by another.

two or three belonging to *Levant* are equally worthy of notice. Perched on the verge and even on the ledges of a tremendous precipice, they seem at the mercy of every storm; and to the beholder from beneath they almost appear suspended in the air and tottering to their fall.

Many of the mining districts in Cornwall afford more employment, and yield greater mineral riches* than that of Saint Just; but in its well-displayed junctions of granite and slate, its veins of granite, of rare and curious earthy minerals, and of metallic ores, its wildly and singularly situated mines,† and their subterranean and subaqueous dangers, and in its bold and romantic cliffs, it is surpassed by none of them in interest and importance.

---

* The Bostrase moors have been streamed for tin-ore with some success; the *tin ground* consists of decomposed granite, which is covered by a layer of peat, and this is succeeded by the ordinary bed of the rivulet. The whole varies from 8 to 12 feet in depth.

See also Mr. Carne, Cornwall Geo. Trans., II. p. 332.

† In one part of Botallack the labourers have to descend to the adit, by ladders placed on the face of the cliff.

LITTLE BOUNDS MINE, PARISH OF SAINT JUST.

Name and Dtn. of lode.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
WHEAL BESANS. 10° N. of W.	30.	S. 76°	12 in.	Quartz, brown iron ore, and oxide of tin. A small *branch* separates to the S., in going towards the W.	Junction of the granite and slate, well defined, dip W. 22°. granite fine grained quartz and felspar, a little mica and crystals of schorl. Slate dark blue compact and traversed by many strings of quartz dipping W.
	—	S. 88°	8 in.	Quartz, with spots of brown oxide of iron.	Slate dark blue very quartoze dipping W.
	70.	S. 86°	10 in.	Quartz confusedly crystalline, oxide of iron, chlorite, and oxide of tin. A vein passes from this *lode* into *Saveall*, bearing 5° S. of W., and dipping N. 58°.	Fine grained pink and buff coloured felspar, a little quartz, and numerous large crystals of schorl.
SAVEALL. 35° N. of W.	30.	N. 65°	2 feet.	Crystalline quartz, schorl, and oxide of tin. A vein from the *North lode* unites with this at an angle of 45°.	Green passing into purple and brown fine grained cleavage dipping W.
	36.	N. 80°	.....	.....	The granite and slate join at an angle of 30° W.; a vein of clay of less than an inch in thickness is interposed between the two. The rocks are well defined.
	70.	N. 80°	2 to 5 ft.	Two veins of clay, alternating with two of quartz and schorl.	Friable, felspar clay with a little quartz and schorl.
NORTH. 33° W. of N.	56.	S.W. 76°	4 in.	Quartz, and oxide of tin.....	Pink and white felspar, quartz and schorl, fine grained.
	70.	S.W. 74°	6 in.	Crystalline quartz	Idem.
LITTLE BOUNDS. N. W.	30.	N.E. 64°	4 in.	Schoraceous granite.....	Red felspar, quartz and schorl, with large porphyretic crystals of white felspar. The lines of structure about 25° W. of N., dip. W. 80°, are from 3 to 20 in. thick.
	58.	N.E. 82°	2 in. to 4 ft.	Quartz, felspar, and brown iron ore...	Red felspar and schorl, much decomposed.

Table I.

HEAL BELLON MINE, PARISH OF SAINT JUST. (*Pl. I. Fig*

Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Little V Dower,
N.E. 83°	14 in.	Confusedly crystalline amethystine	Fine grained white felspar	

WHEAL CASTLE MINE, PARISH OF SAINT JUST.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
LODE, N.W.	50.	N.E. 80°	7.5 ft.	Ferruginous quartz, quartz, brown iron ore, and a little oxide of tin.	Fine grained greenstone slate, cleavage dipping N.W., 10° to 15°, some veins of fine grained schorl rock in the N.E. wall of the *lode*.
	60.	N.E. 73°	6 ft.	A vein of quartz on each side, and between them a vein of ferruginous quartz, in some places containing spots of quartz, and friable iron pyrites.	Fine grained crystalline, but with very imperfect cleavage, in some places decomposing.
	70.	N.E. 64°	4 ft.	A vein of quartz on each wall, the intervening portion of very thin beds of ferruginous quartz, which dip S.W. about 50°.	Coarse grained reddish brown hornblende and felspar, with minute specks of mica.

Table IV.

WHEAL EDWARD MINE, PARISH OF SAINT JUST.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Little Lode.
Lode, 35° W. of N.	11.	N.E. 80°	3 feet.	Brown iron ore, and quartz.....	Deep greenish brown, compact, fine grained, with an imperfectly slaty cleavage.	The two *lodes* unite here, and are not again seen separate.
	25.	N.E. 76°	2.5 ft.			
	45.	P.	6 feet.	Vitreous copper ore, with copper pyrites, pitch blende, ferruginous quartz, and crystals of carbonate of iron in the cavities.	Idem, very quartzose. In a second spot, fine grained, schorl and quartz passing into felspar and quartz.	
	55.	N.E. 68°	7 feet.	In several veins, confusedly crystalline quartz, and oxide of tin.	Slate, deep green, in some places reddish brown, and traversed by numerous minute veins of mica.	
	—	—	10 feet.	N.E. wall, a small vein here unites with the *lode;* which is ferruginous quartz, quartz, and irregular masses and veins of copper pyrites, with traces of vitreous copper ore.	S.W. wall, granite, coarse grained and quartzose.	
	65.	N.E. 78°	12 to 15 feet.	Veins of ferruginous quartz, chlorite, oxide of tin, schorl, crystals of carbonate of iron in the cavities, & traces of vitreous copper ore.	Granite very coarse grained, and confusedly crystalline; mica, and dark brown felspar, abundant.	
	—	N.E. 82°	15 feet.	A vein of ferruginous quartz 8 ft. wide, & one of oxide of tin, schorl & quartz of 2.5 ft. broad.	Idem.	
	75.	N.E. 70°	2 feet.	Quartz, and veins of schorl and quartz	Coarse grained porphyritic granite, large crystals of dark green felspar; traversed by veins of quartz.	
Little Lode, 40° W. of N.	11.	N.E. 68°	2.5 ft.	Quartz, and brown iron ore	Slate, compact pale green, with scarcely a trace of cleavage.	
	20.	N.E. 80°	1.5 ft.	Vitreous copper ore, copper pyrites, with spots of pitch blende and uranite, arragonite, ferruginous quartz, and quartz.		

Table V.

PARK-NOWETH MINE. PARISH OF SAINT JUST. (Dr. I

21.	S. 75°	6 in.	Chlorite, oxide of tin, and crystallized quartz, in a quartzose basis.	A basis of quartz, with large c white felspar, and a little da
54.	S. 56°	6 to 12 inches.	Chlorite, quartz, earthy red iron ore, schorl, pink and white felspar, oxide of tin, with numerous small cavities lined with the earthy phosphate of iron.	Dark green felspar, with large ritic white crystals of th mineral, and schorl.

BOTALLACK MINE, PARISH OF SAINT JUST. *(Pl. I. Fig. 5–6.)*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Wheal Hazard Lode.
				A *vein* of vitreous copper ore, 3 ins. wide, goes off towards *Codna Reeth lode.*	Intersected by a bed of fine grained granite, bearing N. and S. The junction between the two rocks is very distinct, dipping W. 66°.	
	70.	S. 72°	1.5 ft. to 4 ft.	Iron pyrites, vitreous copper ore, and oxide of tin. The former most abundant, when in granite; the latter, whilst in slate.	Idem.	
Codna Reeth, 30° N. of W.	60.	S. 86°	3 in.	Quartz, earthy brown iron ore, and vitreous copper ore.	.....	The two *lodes* continue together on the line of *Wheal Hazard* direction, for 20 fms., the *vein* being 4 feet wide, and its dip. S. 61°. *Codna Reeth* then takes off towards the N. Angle of junction S. 20°, N. 25°. If there be a *heave*, it is 20 fathoms R., G.A.
Flucan, 16° E. of N.	40.	W. 46°	1.5 ft.	Decomposed felspar, ferruginous clay, and friable quartz.	.....	*Lode* divided, but not *heaved.*

* This is the *Guide* which has been already mentioned in *Park-noweth.* (Table VI.)

WHEAL COCK MINE, PARISH OF SAINT JUST. *(Pl. I. Fig. 7–8.)*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Quartz Vein.	Guide.
Tolven,	42.	S.W. 68°	4 feet.	Veins of earthy red iron ore, and	Greenstone, fine grained horn-		
	95.	N.E. 86°	4 to 10 inches.	Confusedly crystalline quartz, earthy brown iron ore, carbonate of iron, and iron and copper pyrites.	Deep green, fine grained, with large irregular masses and veins of quartz.		
Vein,‡ 24° W. of N.	42.	W.74°P.	6 to 10 inches.	Takes off from *Wh. Cock lode* S.; copper pyrites, in earthy red iron ore, and quartz.		*Vein* heaved 9 feet L., G.A.	The *Guide* and *vein* are seen 6 fms. in contact: the former on the W. side.
14° W. of N.	—	W60-70°	—	Vitreous copper ore.			
	49.	W. 60–66°	2 feet.	Quartz, jaspery iron ore, slate, and when in contact with the *Guide*, vitreous copper ore; when separate, copper pyrites.	Deep green, fine grained, and very hard.	.....	Idem.
Quartz Vein 16° N. of W.	42.	S. 70°	6 in.	Confusedly crystalline quartz.			
Guide, 16° E. of N.	42.	E. 80°	4 to 5 feet.	Decomposing greenstone, opening in many joints, which are filled with a green unctuous mineral.	Idem.		
	49.	E. 75°	4 feet.	Idem.	Idem.		

* I am informed that at this spot the *Guide* is cut through by the *Lode*.

† (*a*) and (*b*) refer to the stations so marked in Fig. 8, Pl. I. and Appendix, No. II.

‡ This *vein* is conjectured to be the *Coffin Christa lode* of *Park-noweth* and *Botallack*.

EVANT MINE, PARISH OF [illegible]

Dip.	Size.	Appearance and Composition.	Appearance of Ro
.....	.....	.....	Greenstone, slaty, fine grained, N.E. 26°.
E. 78°	1 foot.	Quartz, jasper iron ore, and earthy red	Deep blue, with reddish bands, an

WHEAL SPEARN, PARISH OF SAINT JUST. *(Pl. II. Fig. 1.)*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Great-work Scorran.	Spearn Scorran.	Noon Reeth Guide.
Wh. Lewer, S.E. & N.W.	25.	S.W. 74°	1 foot.	Schorl, chlorite, quartz, and a little oxide of tin.	Idem.			
Button White's, 20° N. of W.	25.	S. 71°	2 to 5 inches.	Decomposed granite, earthy red iron ore, oxide of tin, and iron pyrites. On separating from the *Guide* E., the *lode* is larger, and the tin ore much more plentiful.	Coarse grained, basis of pale buff felspar, and green quartz, with large crystals of white felspar.	.....	.....	*Lode* bends with the *Guide*, 3 feet R., G.A.
Noon Reeth Guide, 20° W. of N.	24.	W. 70°	2 feet.	Confusedly crystalline quartz, felspar clay, and earthy red iron ore.				
	47.	E. 77°	1.5 ft.	Idem; with a vein of green fluor of 12 inches wide. It accompanies *Lane lode*, and stands on its W. *wall* for 50 fathoms, bearing 40° N. of W.				

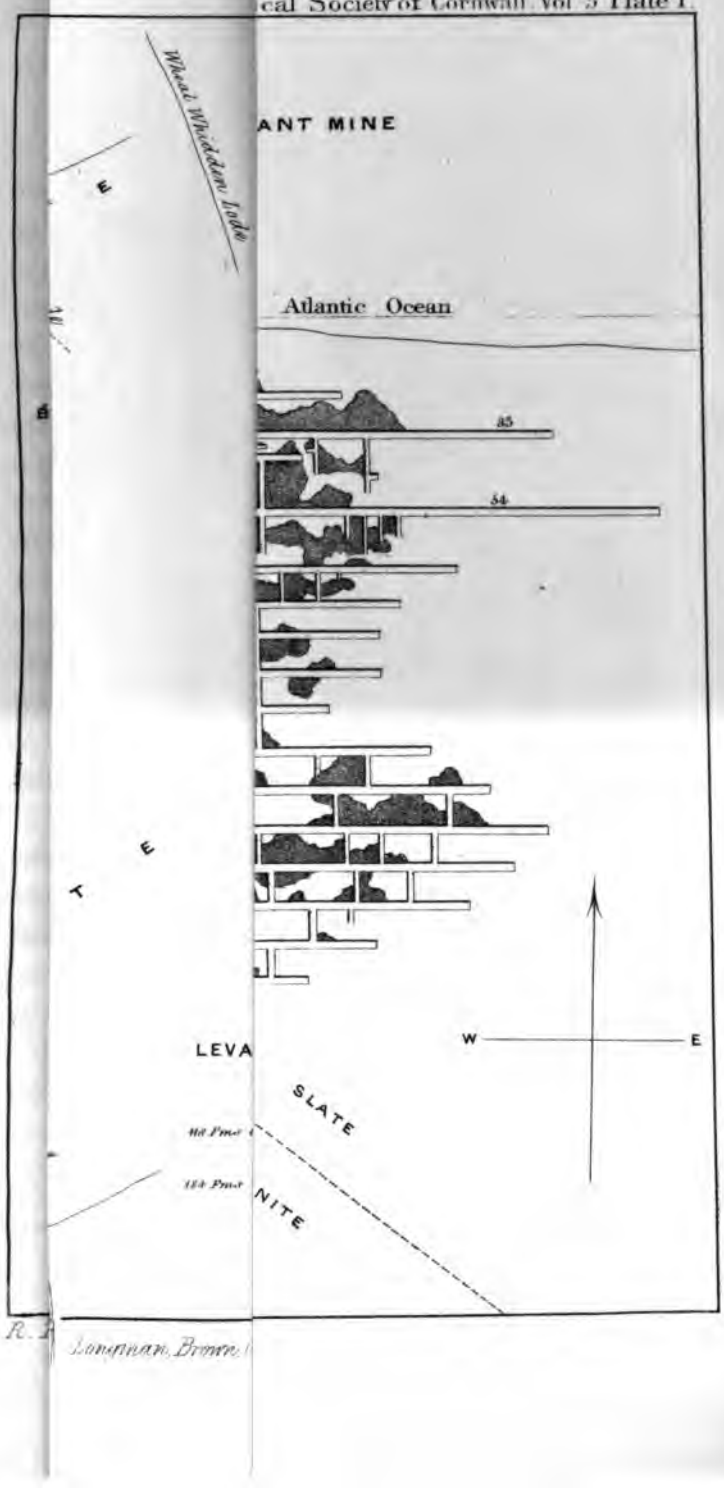
* I am informed that *Spearn lode* is, in this spot, *heaved* 2 fathoms R., G.A.

WHEAL PENWITH, PARISH OF SAINT JUST.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
LODE, 25° S. of W.	14.	S. 56–60°	6 in.	Quartz, earthy brown iron ore, felspar clay, copper pyrites, vitreous, and black ores of copper. W. divided into two *veins*, of which the N. one dips the faster, and they therefore unite in depth. The N. *branch* contains many small hollows lined with the green carbonate of copper.	Granite very coarse grained, basis of felspar, quartz and mica, with numerous large porphyritic crystals of white felspar.

BOSCASWELL DOWNS MINE, PARISH OF SAINT JUST.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Guide.
Lode, 24° W. of N.	26.	E. 84°	3 feet.	Quartz, earthy red iron ore, and oxide of tin.	Granite, quartzose, with pale and buff felspar, and white mica.	The *Guide* bends a little towards the


ANT MINE
Wheal Whidden Lode
Atlantic Ocean
85
84
W
E
LEVA
SLATE
NITE
Longman, Brown

BALLESWIDDEN MINE, PARISH OF SAINT JUST.

The *course* or bed of rock which is called the *lode*, bears about 30° N. of W., and dips S. 60–80° ; it is composed of ill-defined and confusedly mixed crystals of felspar, quartz, a little white mica, and some schorl, among which considerable quantities of oxide of tin are irregularly distributed. This is worked from 12 to 30 feet in breadth, and it is traversed by a great many small veins which have a general coincidence with the mass both in direction and in dip. These are frequently mere lines in the rock, and but few of them are more than 3 or 4 inches wide; they consist almost entirely of oxide of tin, quartz, and schorl, and are generally very rich. They frequently divide, reunite, and possess all the ordinary characters of *lodes*, and the cavities with which they abound are lined with minute but perfect crystals of oxide of tin.*

The contiguous granite is a very coarse grained basis of felspar, quartz, and white mica, with numerous large crystals of white felspar; these are here considered favourable indications, contrary to the general rule of the district, which gives a preference to that mineral, when pink, brown or buff coloured.

Both the veins and the granite are traversed by lines of structure, which bear about 20° W. of N.

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* Captain James Wall, to whom we are indebted for the discovery of all the rare and curious minerals of this district, has detected a few very small crystals of the sulphuret of bismuth among the tin ore of this mine.

... at its north-easte
and comprizing the parishes of Saint
and Towednack.*

The tract in which mining is carrie
generally of upland heaths, occasionall
cairns of considerable elevation, whos
are covered with enormous masses of g
dently *in sitû*, but separated from th
(parent) rock by disintegrated granite
often many feet in depth. This district
except towards the N. and E., where it
row border of slate on the sea coast.† T
s generally very coarse grained and porp
which structure good examples may be s
ose stone hedges which enclose the
tches under cultivation near Halse-t
herever much of the surface is exposed,

For convenience I have included in this district the *Unit*
in the parishes of Morvah and Zennor, and *Ding Dong*
ral; for although not within the limits here described, th
e same granitic range, which extends from the Land's-end t

† 'From the head land nearly opposite the Carracles to
killas rocks prevail without interruption; but the denud
er two instances sufficiently near the central ...
is of granite."—Pr...

places in hornblende, in others, with actynolite, and mixed with small quantities of some other minerals. These have been already described in the last district, and some of them are compact, whilst others are slaty and dip towards the N.E.

The actual junctions can no where be seen at the surface, but in the rocks which occur between Knill's monument and the sea near the *Providence Mines*, the nature of the transitions may be clearly traced.

The joints or lines of structure in the granite are well exposed at Halse-town, and on the craggy summits of Trencrom, Trink, Rosewall,* and Penbeagle; and in the slate, in the cliffs near Saint Ives, and on the beach towards Lelant church. One system of these planes bears between (true) N. and N.E.; but a second series with rather more constancy *strikes* about 10° S. of W.; whilst a third, sometimes appears at from 20° to 30° N. of W. There is, however, no great constancy in their directions, for especially in the same mass of slate the frequent intersections of innumerable smaller joints occasion much irregularity and apparent curvature; and in the granite of the same cairn, a difference of from 15° to 20° in the bearing of the structural divisions is by no means uncommon.

The directions of the *lodes* are rather to the N.

* It is not very generally known that there is a *Logan-rock* on the eastern summit of Rosewall hill. It is a wedge-shaped mass, decomposed on the edges, about 12 feet long, 6 feet wide, and 4 feet thick at one end, but diminishing to 6 inches at the other. Its weight may be estimated at twelve tons, and it is easily set in motion by the hand.

fields. In *Balnoon* the distribution is, perhaps, even more unusual; for besides occasional enlargements of the *lodes* from a few inches to 30 or 40 feet in breadth, there are still larger masses of tin ore wholly unconnected with any vein, and surrounded on all sides by an extremely hard and very coarse grained granite.* These are discovered almost by accident, for I have known more than one of them found by extending the excavation where there existed no other indication than a mere joint in the rock, which contained no mineral, and was perceptible only from the slow oozing of a minute quantity of water between its faces.

The ores in all well ascertained cases, dip eastward, towards the slate.

The only excavations extended beneath the sea are at the *Providence Mines*, in which there is a considerable influx of salt water at the 32 fathom *level*:† in all the other mines in this district, the quantity of water is but small.

Wheal Union and *Wheal Reeth* are situated near the summits of Rosewall and Trink, *Wheal Trenwith* near and parallel to a deep glen, *Balnoon* and *West Poldice* are intersected by small vales; all the other mines are on gentle declivities.

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* Mr. Hawkins, Cornwall Geo. Trans. II. p. 31. Dr. Boase, Treatise on Primary Geology, p. 191.

† "*Huel Providence Copper Mine* (not now at work) is the first which occurs "on the north coast, it is situated between Saint Ives and Hayle. Here there "are two levels at the depth of 24 and 32 fathoms under high water mark, "both of which are driven about 20 fathoms under the sea. The water was "not salt, and the workmen could scarcely hear the noise of the waves."

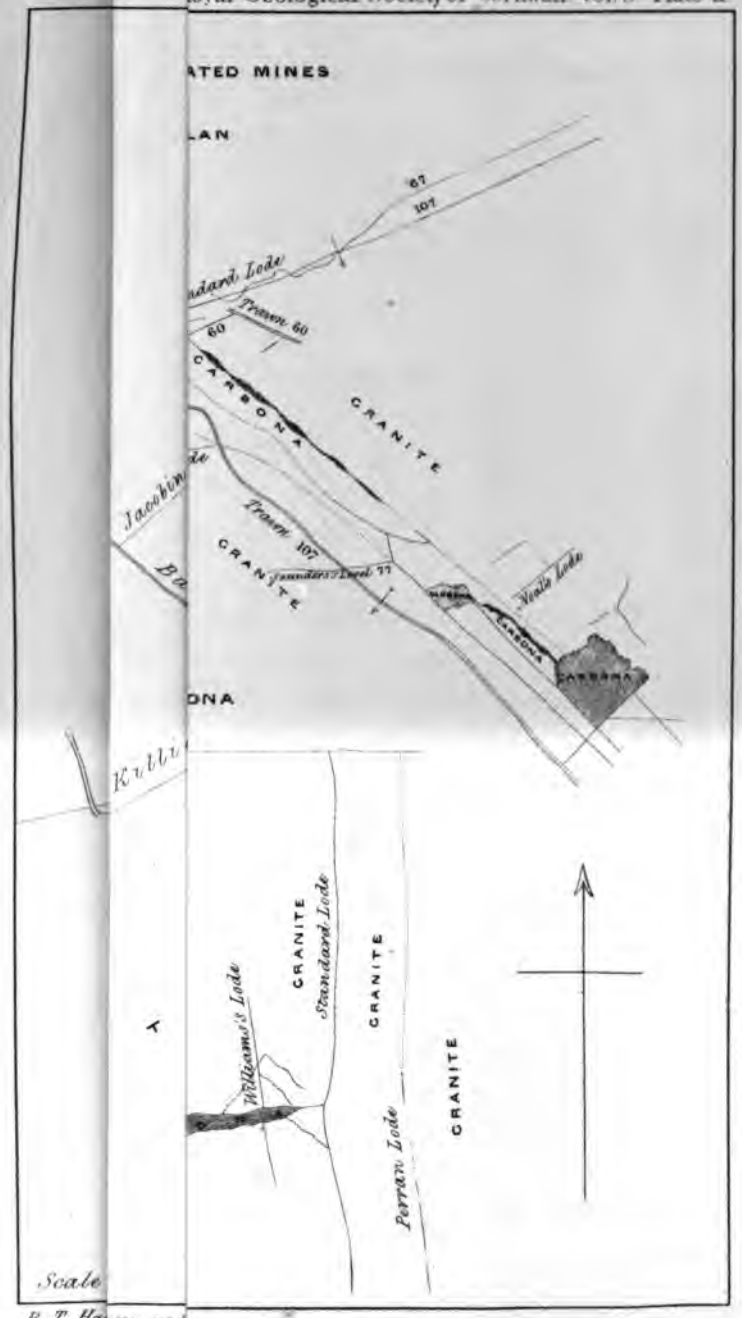
Mr. Carne, *Cornwall Geo. Trans.* II. p. 344.

DING DONG MINE, PARISHES OF MADRON AND GULVAL. *(Pl. II. Fig. 2–3.)*

SAINT IVES CONSOLIDATED MINES, PARISH OF SAINT IVES. *(Pl. II. Fig. 4–5–6.)*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Standard Lode.	Perran Lode.
Standard Lode, 25° S. of W.	65.	N. 78–84°	6 in. to 2.5 ft.	W. Quartz, red felspar, earthy red iron ore, iron pyrites, and oxide of tin.	Granite, coarse grained, porphyritic, basis greenish-brown felspar, and quartz; with large crystals of white felspar, lines of structure 20° N. of W.		
			1.5 ft.	tle oxide of tin.			
Perran Lode, 25° S. of W.	75.	P.	12 to 20 in.	Quartz, schorl, brown felspar and oxide of tin.	Idem; the crystals of felspar all dip N.		
	125.	N. 80°	—	Idem.			
Western Trawn, 20° W. of S.	75.	W. 68–84°	15 ft.	Disintegrated granite, abounding in felspar and mica.	.....	*Lode heaved* 6.5 fms. L., G.A.	
	95.	W. 68–75°	—	Idem: in three veins, including masses of granite between them.	.....	6 fms. L., G.A.	
Middle Trawn, 40° S. of E.	75.	S.W. 40–55°	5 to 8 feet.	Disintegrated granite, felspathic and containing much mica.	.....	The three veins are all *heaved* R., G.A. S. *vein* 2 fms. Mid. — 3.5 — N. — 6 —	*Lode heaved* 4.5 fms. R., G.A.
	125.	S.W. 45–60°	? fms.	Idem.	.....	8 fms. R., G.A.	6.5 fathoms R., G.A.

* See page 21 of this Volume.


ATED MINES
LAN
67
107
Standard Lode
Drawn 60
60
CARBONA
GRANITE
Jacobin
Drawn 107
GRANITE
Saunders's Level 77
Veale Lode
CARBONA
CARBONA
ONA
Kibbl
GRANITE
Standard Lode
GRANITE
Williams's Lode
Perran Lode
GRANITE
Scale
R. T. Hamice, and

It is, I fear, hardly possible to give a clear description of the extraordinary deposit of tin ore which is connected with the *lode* of the *Saint Ives Consolidated Mines*, and has obtained the name of the *Carbona*.* It joins the *Standard lode* at the depth of 78 fathoms, and at the junction the connecting surface is not more than 4 or 5 inches square. From that place it has been worked perhaps 120 fathoms in a south-easterly direction; until, tending continually downwards, it reaches the depth of nearly 100 fathoms. Its greatest vertical extent is about 10 fathoms, and its largest width is about the same; but the average dimensions may be 4 fathoms high, by 10 or 12 feet wide. It has a dip varying from 45° to 80° towards the S.W.; and its bulk is subject to extreme irregularity. *(Pl. II. Fig.* 4–5–6.)

It exhibits few of the usual characters of a *lode*, as it is bounded above, below, and on either side, by the ordinary granite. It is chiefly composed of felspar, quartz, schorl, and oxide of tin, very irregularly aggregated; but in many parts contains fluor (which the *lode* does not) chlorite, common and blistered copper pyrites, iron pyrites, and here and there traces of vitreous copper ore.

* This term, as far as I can learn, was first applied to a somewhat similar deposit, which was many years ago discovered in *Rosewall-Hill Mine*. It is now used in this district to designate the, here, not unusal occurrence of tin ore in irregular masses which do not possess the general characters of *lodes*. The prevalent opinion that it was a *cant* term used by the miners and has no definite meaning, is probably correct. Some, however, pretend to trace its derivation from the ancient Cornish language.

About 80 fathoms from the *lode*, it falls in with the *Middle Trawn*, and takes the direction of that vein. They continue side by side for 25 fathoms, the *Carbona* standing on the west. The *Trawn* then contains stones resembling the substance of the *Carbona*, and in a few fathoms further the disintegrated and very felspathic granite of the former is gradually and entirely replaced by schorl, quartz, felspar, and oxide of tin, and other minerals which occur in the *Carbona;* whilst their joint direction still continues that of the *Trawn*.

At length the *Carbona* takes a bend and goes off at right angles, towards the N.E.; whilst the *Trawn* continues its original direction, and becomes more and more granitic; and although it for some fathoms still retains some traces of the mineral composition of the *Carbona*, at last it re-assumes its usual disintegrated and felspathic characters.

Immediately east of the *Trawn* the *Carbona* increases to enormous dimensions, and is worked for at least 10 fathoms in length, breadth, and height. The scattered lights, the great number of miners in their soiled and torn working dress, the pillars and beams of wood which support the roof and *walls*, and the rock lining this vast cavern, all dimly discerned (at intervals) by flickering and uncertain gleams, produce a most striking effect.

From this large mass *shoots*, *branches*, *bunches*, and other irregular protuberances strike off in every direction; and wherever there is an unusual enlargement of the *Carbona*, such is invariably found

nds with it where granite is more uniform in ggregation, and the felspar pink or pale green. he whole may be described as forming a net- of *pipes, strings, branches, shoots* and *veins,* erging into one grand trunk, which extends to S.E., dipping about 1 in 6, and is on all sides ounded by the hard granite, but no where hes the surface.

BALNOON MINE, PARISH OF LELANT,

been from time immemorial remarked for the rently irregular and capricious distribution of in ore it affords. This however is not exactly that of the *Carbona* in the *Saint Ives Consoli- d Mines;* but has a greater similarity to the nary characters of veins.

e Course vein bears about 25° E. of (true) N.

and mica, with embedded crystals of pink felspar; whilst the reverse occurs when large porphyritic crystals of white felspar abound in the granite.

The *North Vervis lode*, however, in the deeper parts seems to have a limit both on the E. and on the W. At 60 fathoms deep, although it widens to 20 feet for 10 or 15 fathoms, then contracts to but a few inches wide for 6 or 8 feet, and again enlarges to 30 feet in breadth for 10 fathoms; yet at 80 fathoms deep it is at last completely surrounded on the ends, sides, and bottom, by the hard granite, without leaving the slightest trace of its further existence in any direction.

It is by no means easy, if indeed it be possible, to convey an adequate idea of the irregularity of these formations: and I fear it is vain for me to hope that the description I have here attempted will answer any other purpose than to show that they have but a remote resemblance to *lodes*, or to any other kind of deposit in which tin has been hitherto found to occur.

WHEAL TRENWITH, PARISH OF SAINT IVES.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	North Branch.	South Branch.
	85.	N. 76° to S. 80°	6 to 12 inches.	Quartz, slate, and earthy red iron ore.	Idem.		
	95.	N. 70° to S. 82°	6 to 12 inches.	Idem.	Idem.		
	105.	N. 82–86°	6 in.	Idem.	Fine grained, hard, opening in angular blocks, with earthy red iron ore in the joints.		
TRAWN, 30° W. of N.	25.	W. 60°	12 fms.	Slaty matter, and earthy red iron ore.	Greenstone, compact, and rather decomposed.	11 fms. R.,G.A.	4 fms. R.,G.A.
	35.	W. 70–78°	6 feet.	Slaty matter and a little quartz...	Deep green, compact.....	9 fms. —	5 fms. —
	45.	W. 53–60°	4 feet.	Quartz, and slaty clay.....	.....	14 fms. —	11.5 fms. —
	55.	W. 50-80°	3.3 fms	W. side, a great many veins of quartz, two feet wide; the remainder decomposed slate, in which however there are no traces of the *lode*.	Deep green, compact.....	11 fms. —	
	65.	W. 56–68°	1 fm.	W. side, veins of irregularly crystalline quartz; the E. portion, slaty clay.	Deep green, fine grained, with obscure traces of a slaty cleavage.	*Heaved*, how far?	
	75.	W. 52–76°	3.3 fms	Idem.			

* Eastward there is but one *vein;* but westward it is divided into two; which in some places again unite.

† See note on page 19 of this Volume.

‡ Dr. Forbes, Cornwall Geo. Trans. II. p. 264.

WHEAL MARY, PARISH OF LELANT.

.	Size.	Appearance and Composition.	Appearance of Rock.
32°	10 to 16	Greenish-brown felspar, quartz, schorl,	Granite, rather coarse grained, and abou

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Trawn.
Lode, 40° S. of W.	24.	N.W. 78–86°	6 in.	Quartz, earthy red iron ore, brown felspar, and oxide of tin, opening in smooth striated joints.	Granite, coarse grained basis of greenish felspar, quartz, mica, and schorl, with large crystals of pale buff felspar.	
	40.	N.W. 78°–P.	6 in. to a mere line.	Quartz, schorl, oxide of tin, earthy red iron ore, mica, and pink felspar.	Coarse grained, with numerous large crystals of white felspar. E. fine grained pink felspar, quartz, and mica.	
	50.	N.W. 64–83°	1 foot.	Quartz, schorl, and oxide of tin: a vein of felspar clay on the N.W. *wall.*	Coarse grained, basis of pink felspar, and quartz, enclosing large crystals of white felspar.	*Lode, heaved* 1 foot L., G.A.
	60.	N.W. 72-84°	3 in. to 1.5 ft.	Quartz, oxide of tin, schorl, and disintegrated granite in irregular masses.	Soft, with large quantities of quartz, and mica.	
	—	N.W. 68–70°	6 in.	Quartz, oxide of tin, and large quantities of schorl.	Idem, felspar greenish grey.....	1.5 foot —
	70.	N.W. 76–82°	A line to 2 ft.	Quartz, schorl, oxide of tin, and *bunches* of disintegrated granite.	Idem.	
	80.	N.W. 76–86°	10 in.	Oxide of tin, in earthy brown iron ore, and quartz.	Coarse grained, basis of greenish felspar, with large crystals of buff, and pale pink felspar. The rock on the N.W. of the *lode* opens in joints parallel thereto.	
					Very coarse grained, basis of green felspar.	

Table XX.

The tract which I have called

THE MARAZION DISTRICT,

Comprises the slate-rocks which are bounded on the west and north by the granite of Paul, Madron, Gulval, and Ludgvan parishes; and on the south by the Mount's-Bay. It extends eastward to the valley which runs from Relubbis towards Hayle.

The structure of the slate formation on the shores, its junctions with the granite at Mousehole, and Saint Michael's Mount, and its connection with the porphyry *(elvan)** at Penzance, are well exposed, and have been frequently described.†

The granite is of the ordinary kind, composed of felspar, (its prevailing mineral) quartz, mica, and sometimes schorl and pinite. Except at Saint Michael's Mount where the texture is much finer, it is rather coarse grained, but much less so than in the Saint Just district.

The slate-rocks which touch the granite are generally massive greenstones, which are composed of hornblende and felspar in varying proportions, and contain many other minerals in regular veins; and

* Throughout the mining districts of Cornwall the dykes or veins of porphyry have the provincial name of *elvan*, a word of uncertain derivation.

† Dr. Berger, Geo. Trans. o.s. I. pp. 143–145. Mr. Majendie, Cornwall Geo. Trans. I. p. 25. Mr. Hawkins, Ibid. p. 136. Mr. Carne, Ibid. II. pp. 69–79. Dr. Forbes, Ibid. p. 267. Prof. Sedgwick, Cambridge Phil. Trans. I. pp. 108–113–118–134. Mr. Carne, Cornwall Geo. Trans. III. p. 242. M. M. Oeynhausen and Dechen, Phil. Mag. and Annals v. (1829) pp. 162–243. Dr. Boase, Cornwall Geo. Trans. IV. p. 353, and Treatise on Primary Geology, pp. 127–152–172. Mr. Bakewell, Introduction to Geology (4th ed.) p. 92, and Mr. De la Beche, Geo. Manual, (3rd ed.) p. 460.

a few distributed in more irregular modes. Viewed as a whole they may be regarded as varieties of greenstone, often assuming a slaty cleavage; but no regular order of succession seems to prevail in the massive and schistose varieties: the accidental minerals (if they may be called so) seem generally to occur in the former.

At the Lariggan rocks the hornblende appears to be replaced by actynolite, which is mixed, and in some cases almost superseded by axinite; and these minerals seem regularly mixed with the felspar. In other spots, *e.g.*, at the Penzance gas-works, and at the Greebe rock, the axinite and actynolite are collected in distinct veins and masses.

Towards the eastern extremity of the district, and at some distance from the granite (whether it be the great mass which forms the larger portion of the western peninsula, or the smaller patch of Saint Michael's Mount) the greenstone rocks are succeeded by very schistose rocks of a deep blue colour and very silky lustre.* These are more frequently traversed by veins, strings, and irregular masses of quartz, which sometimes fall in and associate with the metalliferous deposits, and form integrant parts of the *lodes*, as in *Wheal Darlington*, (*Tab.* XXIV.,) the *Marazion Mines*, (*Tab.* XXV.,) &c.

The cleavage of all the schistose rocks of the

* The mines which are worked in the schistose rocks invariably afford more water than those in the massive. At *Wheal Darlington* the water issuing from the *cross-course*, at the depth of 90 fathoms is extremely salt, whilst that from the *lode* at but a foot or two distant is very much less so, although this also contains salt.

MARAZION MINES, PARISH OF SAINT HILARY.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Flucan.
VIRGIN LODE, 20° S. of W.	20.	S. 64-74°	1 foot.	Quartz, earthy brown iron ore, and black copper ore. The latter most abundant when the contiguous rock is *elvan*.	Slate, homogeneous deep blue, cleavage dipping S. 8–14°. E. *Elvan*, basis of green felspar and (?)	

The granite and the slate are alike traversed by several *elvan courses*. Mr. Carne* mentions one at Bosava, in Paul; and Dr. Boase† describes another at Mousehole, which are both in granite. The best known and most frequently described *elvan* in Cornwall, after passing under the pier at Penzance, is visible for a considerable distance on the shore

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" the slate. In some places there is a mere opposition without intermixture of " the two rocks; in others the intermixture is so complete as to render it im- " possible to say to which of the two certain considerable masses belong."

DR. FORBES, *Cornwall Geo. Trans.* II. p. 367.

" Saint Michael's Mount is a fine instance of veined granite, and of the " varieties of rock which arise from such a texture. It affords also a very " striking illustration of the fact, that veins which have every appearance of " being contemporaneous, often, for a considerable extent, preserve a paral- " lelism among themselves. It must at the same time be observed, that the " largest veins which range in a direction nearly east and west, are accom- " panied by fissures, which divide the whole Mount into parallel vertical " beds. Between these beds are found oxide of tin, wolfram, apatite, the " topaz, and some of the rarer minerals of the county."

PROF. SEDGWICK, *Cambridge Phil. Trans.* I. pp. 108–109.

* " In general it contains scarcely any mica, but a great deal of schorl, " which rarely appears mixed up with other parts of the granite, but in small " separate bunches; in some parts it appears to consist of quartz, schorl, and " mica, and to contain no felspar; another variety exhibits schorl, felspar, and " mica, with scarcely any quartz. This granite has been seen about ten feet " below the surface where it is found in irregular laminæ, much like the " common elvan stone, and indeed this is almost the only circumstance in " which it resembles the porphyritic elvan of the mining district: it is, for the " most part, equally tough, and as easily wrought, as other granite. It occurs " in a regular channel, of which it is difficult to ascertain the width; but from " the appearance of the surface, I think it cannot be less than from 150 to 200 " feet. Its direction is about north-east and south-west."

Cornwall Geo. Trans. III. pp. 242–243.

† " The several granite veins, for the most part, consist of compact felspar; " which, in some places, is very quartzose, but seldom porphyritic. The large " northern vein or elvan, however, often abounds in crystals of felspar. * * " The elvan appears to occupy the declining surface, as it dips northward, so " as to cross the laminæ of the slate: and it is worthy of remark, that the " strike of the slate generally winds round this granitic promontory; so that, " approaching St. Paul, it becomes N., and at length N.W.; which fact may " account for the deviation of the elvan from a course parallel with the granite " veins."

DR. BOASE, *Primary Geology*, pp. 153–158.

westward,* and at the *Wherry Mine* it is worked for the tin ore which is disseminated through it.† In the eastern part of the district several *elvan courses* are known. There is one at *Great Wheal Fortune*,‡ a second at *Gwallon*,§ and a third near the *Marazion Mines*.‖ In *Wheal Darlington*¶ there are three, which are probably the westerly extensions of those which appear in the three mines before mentioned, and it seems likely that the Penzance pier *elvan* is the still western prolongation of one of them.

All of them consist, more or less, of a fine grained basis of felspar and quartz, and contain large porphyritic crystals of felspar, double-pointed crystals of quartz,** with nests and spiculæ of schorl; but in the aggregation of the minerals, and in the hardness of the rock, the same *course* presents frequent irregularities,—they all bear about S.W.

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* "Immediately at the back of the pier it *(the elvan)* may be seen stretching "N.E. and S.W., and inclining at a great angle northward. It is a porphy- "ritic felsparite (felspar porphyry), the imbedded crystals being small and "white: these gradually disappear towards the sides of the bed, till at last "this rock is a plain compact felsparite, very hard, apparently in consequence "of an excess of silica in its composition; and in this part, veins of quartz are "frequent, as is also the case in the adjoining stratum of compact actynolite "rock, at the point of their junction, where these rocks can only be distin- "guished from each other by the blue colour of the latter, * * * in some "points the line of junction between the elvan and the slate bears N.E. by E.; "or even N.E., as at the back of the pier; the general direction of the whole "course, however, is E. by N., and W. by S."

DR. BOASE, *Primary Geology*, p. 50.

† Mr. Hawkins, Cornwall Geo. Trans. I. p. 136. Mr. Carne, Ibid. II. pp. 79–80–82. Dr. Forbes, Ibid. II. p. 271. M. Fournet, Etudes sur les dépots Métalliféres, p. 112

‡ This Volume, Table XXIX. § Ibid. Table XXXI. ‖ Ibid. Table XXV. This is quarried for building purposes. ¶ Ibid. Table XXIV.

** Double-pointed crystals of quartz are seldom found except in *elvan-courses*, but in them they occur in almost every locality with which I am acquainted.

The most considerable metalliferous deposit yet known in the granite of this district, is at the *Garth Mine*,* near Burias bridge. The *lode* ranges about 25° S. of W., dips S. 65–80°, and has been worked to a depth of 30 fathoms. It is from 4 to 12 feet wide, and composed of veins of pale buff coloured felspar and quartz, among which are disseminated the small botryoidal concretions of wood tin which occur principally in the felspar veins. The *lode* has been most productive near a *cross-course* which intersects it.

Some small excavations have also been made at Tredavoe, and near Mousehole, but hitherto without much success.

Near Newlyn the greenstone is traversed by some large veins of quartz, on one of which some trials have been made, and small quantities of copper pyrites extracted from it.

The principal metalliferous deposits are, however, in the slate-rocks near Marazion and Goldsithney; the eastern part of the district. The *lodes* generally bear about 20° S. of W., and dip towards the south at various angles;† they usually produce copper pyrites, but where they come into contact with *elvan* they yield vitreous copper ore also. Most of them contain the oxide of tin dispersed in considerable quantities among the copper ores. In all, the general dip *(shoot)* of the ore is towards the east.

There are some *cross-courses* and *flucans*‡ but they are not numerous.

* Mr. Carne, Cornwall Geo. Trans. IV. p. 97.
† There are curious intersections of *lodes* in *Wheal Darlington*, Table XXIV.
‡ *Flucans*, are *cross-veins* composed of clay.

None of the *elvan-courses* are metalliferous except that at the *Wherry* mine, where the masses and veins of the oxide of tin, which are distributed through it without regularity, rather appear to follow the intersection of the *elvan** by the *Black lode.*

At *Gwallon* mine,† the *lode* reposes conformably on the *elvan* for a very considerable distance; and at *Great Wheal Fortune,*‡ when the *lode* stands between *elvan* and *slate,* the part in contact with the former yields vitreous copper ore, and that which joins the slate affords copper pyrites.

The joints or lines of structure which intersect the rocks and veins, separating them into quadrangular masses, have perhaps been observed in no other district so accurately as in this.§

The situations of the mines are very various; *Great Wheal Fortune, Rospeath, Gwallon,* and the *Marazion Mines,* are on hills of small elevation, and *Wheal Bolton, Retallack, Wheal Darlington,* and *Wheal Elizabeth,* are on low lands and gentle declivities.

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* Mr. Carne correctly describes the dip of this *elvan* towards the *north.* Cornwall Geo. Trans. II. p. 82. † Table XXVI. ‡ Table XXIX.

§ At St. Michael's Mount, "in the greater part of the western precipice, "the decay of the veinstones has left wide and deep fissures in the rock, which "are seen traversing it from top to bottom, and dividing it into vertical plates "or masses." DR. FORBES, *Cornwall Geo. Trans.* II. p. 371.

"The elvan (on the beach at Penzance) is traversed by lines or joints, which "cross it in the direction of S. by E., and N. by W.: these lines are, in one "spot, very close together, and there the porphyry is much stained with oxide "of iron, and is in a decomposing state; and the rock adjoining is similarly "circumstanced. Where the elvan is a well-characterized porphyry the lines "are further apart,—that is, the elvan is composed of larger concretions. But "the most important circumstance concerning these lines is, that they, in innu-"merable places, continue their course uninterruptedly into the slate."
DR. BOASE, *Primary Geology,* p. 52.

At Mousehole, "both the granite and the slate are traversed by fissures, or "joints parallel with the granite and quartz veins, which intersect the mass at "right angles. Sometimes these lines correspond with the point of junction, "but very often they pass indifferently through either rock." Ibid. p. 153.

I here conclude the observations which strictly belong to my subject; but I wish to add that a bed of *stream tin ore*, of very inferior produce, some 20 or 30 feet above the sea-level near Newtown, on the Marazion green, has for many years afforded employment to a few persons; and that in the vale between *Wheal Darlington* and the *Marazion Mines* there is a thin and poor bed of *tin-ground* resting on the *shelf** at about the sea-level; on this is laid a bed of vegetable matter containing the trunks and branches of oak, willow, hazel, and perhaps other trees, and nuts in abundance; this is again covered to the level of the slimy soil bearing the present vegetation by sea-sand mixed with shells.

A submarine bed of vegetable remains is well known to exist under the beaches of both the eastern and western greens.†

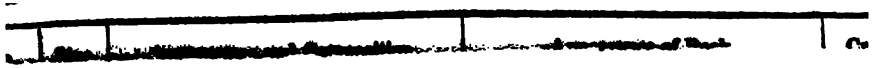
Layers of pebbles and boulders are met with at Mousehole, a little above the ordinary high-water,‡ and at Morrab Place, in Penzance, at least 80 feet above the sea-level. These, however, may be the effects of some flood, and not owing to any changes in the relative levels of land and sea at various epochs.

The scenery of this district is altogether unlike that general in the mining tracts of Cornwall. They are commonly wild, barren, and uncultivated heaths; but this presents a gentler aspect, and its high culture and luxuriant vegetation well entitle it to be called "the garden of Cornwall."

* The bed of *stream tin ore* is called the *tin-ground;* and the rock on which it rests, the *shelf.*

† Dr. Borlase, Natural History, p. 222. Dr. Barham, Cornwall Geo. Trans. III. p. 101. Dr. Boase, Ibid. p. 171.

‡ Mr. Carne, Cornwall Geo. Trans. III. p. 235.



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RETALLACK MINE, PARISH OF SAINT HILARY. (*Pl. III. Fig. 3.*)

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Flucan.
LODE, 22° S. of W.	20.	N. 68–74°	2 feet.	W. Earthy brown iron ore, quartz, black copper ore, copper and iron pyrites, and slaty clay.	Pale blue slate, opening in very thick masses; dip of cleavage N. 14–22°.	*Lode heaved*, 7 fms. R., G.A.
	—	N. 74°	8 in. to 1 foot.	E. Granular quartz, slaty clay, and iron pyrites.		
	33.	N. 52–68°	1 foot.	W. Slate, granular quartz.....	Deep blue slate, which is rapidly decomposed in the joints; dip of laminæ N. 22°.	— —
	—	N. 72–80°	10 in.	E. Slate, quartz, black copper ore, and a little copper and iron pyrites.	Idem.	
	43.	N. 80°	1.5 ft.	W. Black copper pyrites.	[illegible]	— —
	—	N. 80–84°	10 in.	E. Slate, qu[illegible] iro[illegible] per pyrites		
	53.	N. 80°	4 to 9 inches.	Quartz, slate, [illegible]		
FLUCAN, 25° W. of N.	20.	W. 80–84°	4 in.	Pale slaty clay.....	[illegible]	
	33.	E. 82–84°	10 in.	Idem.		
	43.	E. 80–84°	4 in.	Idem.		

Table XXX.

WEST GODOLPHIN MINE, PARISH OF SAINT ERTH.

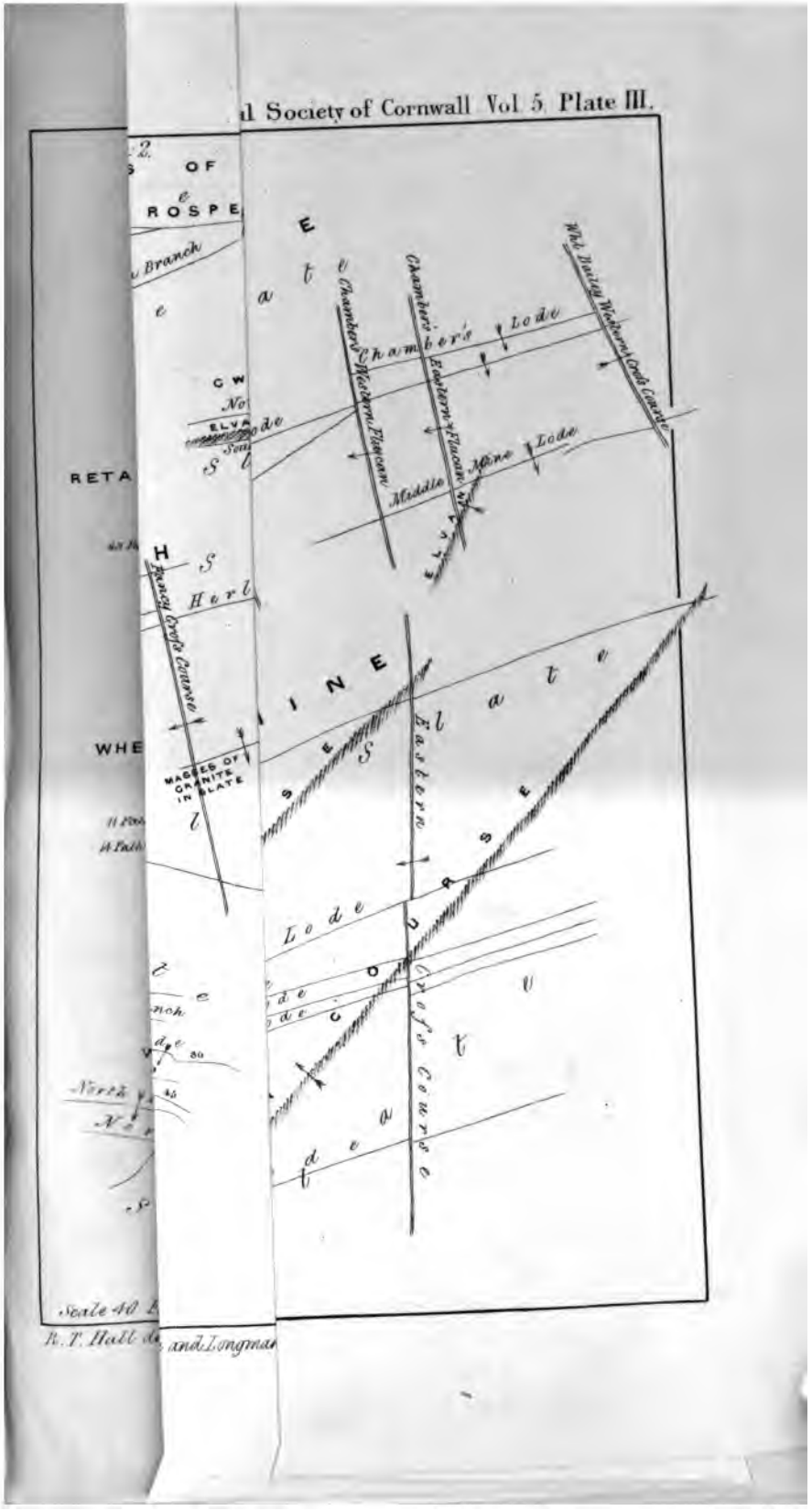
Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
Lode, 25° S. of W.	7.	S. 59-85°	10 to 20 inches.	Quartz, *capel*, (hornblende and quartz) and earthy brown iron ore.	
	—	—	—	Quartz, earthy brown iron ore, iron pyrites, spots of black copper ore, and green carbonate of copper.	
	17.	S. 73–86°	12 to 18 inches.	Quartz, slaty clay, chlorite, iron and copper pyrites, a little blende, and galena. In one spot the slaty clay separated from the *lode*, towards the N., but it rejoined it at a little distance.	Greenstone, generally compact, but in some few spots slaty (opening in the joints only); dip of cleavage N.W. 30–31°. In some places it is variegated green, brown, and white felspar, hornblende (?) chlorite, and traces of
	27.	S. 75-85°	—	Split into *branches* slate, and a littl	

WHEAL ELIZABETH, PARISH OF SAINT ERTH. *(Pl. III. Fig. 4.)*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Lode.
Lode, 25° S. of W.	4.	N. 58–62°	4 to 10 inches.	Slaty clay, quartz, and iron pyrites.....	Slate, deep blue, thick lamellar; dip of cleavage N.W. 12°.	
	—	N. 62–84°	4.5 ft.	W. Smooth but uneven *walls*, earthy brown iron ore, quartz, chlorite, black copper ore, copper pyrites, blende, and galena. The galena, and sometimes the blende are some places imbedded in the black copper ore; a vein of slaty clay of 4 inches wide on N. *wall*.	Idem, N.W. 24°; dip S.W., also deep blue and quartzose.	
	14.	N. 62–74°	2.5 to 3 feet.	W. Quartz, in some places hard, in others soft, with galena in crystals in the cavities; in the hard, quartz, copper pyrites, & blende. On N. *wall* vein of slaty clay.	Deep blue; dip N.W. 14-24°.	
	—	N. 70°	5 feet.	E. A vein of slaty clay N. *wall*, quartz, chlorite, with copper and iron pyrites, and native copper imbedded in them. *(a)**	Soft, blue; dip of cleavage, N.W. 18°.	
	—	N. 68°	—	Copper and iron pyrites, galena, quartz, and slaty clay; the galena on the N. *wall*.		
	—	—	6 feet.	Copper pyrites in chlorite and quartz, with slaty clay—quartz crystalline. *(b)**		
Flucan, 35° W. of N.	14.	N.E. 82–84°	4 in.	Slaty clay, and a little granular quartz.....	.....	*Lode heaved*, 3 feet R., G.A.
W. Flucan, 35° W. of N.	14.	N.E. 82–86°	10 in.	Slaty clay, and quartz.....	.....	*Lode heaved*, (?) R., G.A.

* (*a*) and (*b*) refer to the spots so marked in Fig. 4. Pl. III. and Appendix No. II.

Table XXXII.


OF
ROSPE
Branch
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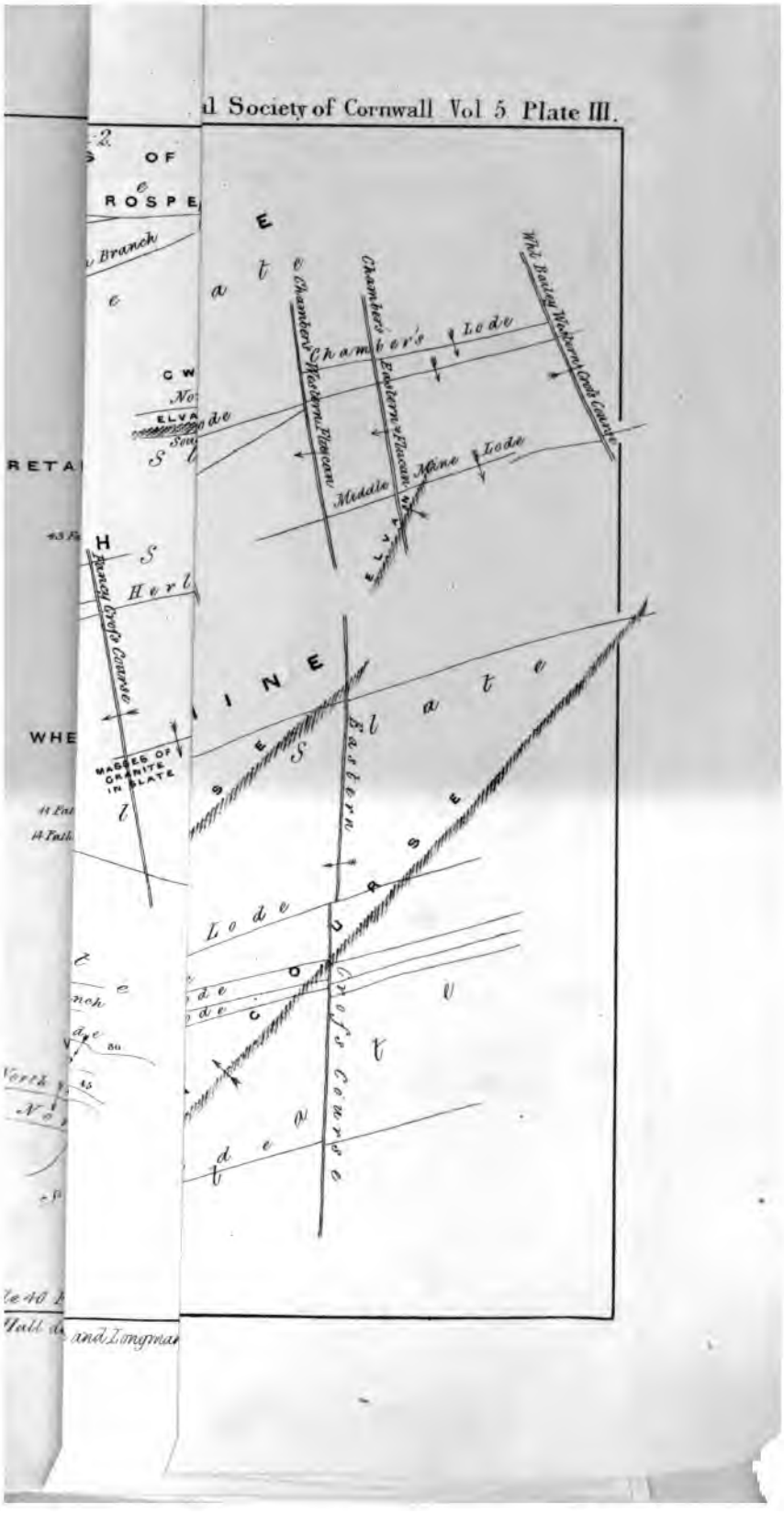
WHE
Chambers Western Flucan
Chamber's Eastern Flucan
Chamber's Lode
Wh. Darcy Western Cross Course
Middle Mine Lode
Darcy Cross Course
MASSES OF GRANITE IN SLATE
Slate
Lode
Cross Course
Scale 40
R. T. Hall
and Longman


l Society of Cornwall Vol 5 Plate III.
Chamber's Eastern Placers
Chamber's Lode
Wh. Bailey Western Cook's Course
Middle Mine Lode
Percy Cross Course
MASSES OF GRANITE IN SLATE
Eastern Lode
Wolf's Course
and Longman

THE GWINEAR AND CROWAN DISTRICT,

Comprizes the parishes of Gwinear and Crowan and a part of Phillack. It is bounded on the north by the Bristol Channel, on the east by an imaginary line drawn from the sea to the eastern end of Clowance-wall, on the south by the brook which divides Crowan from Breage, and on the west by the river which runs from Relubbis to Hayle.

It consists of a group of slate-rocks subordinate to the granite of Crowan, and is intersected by a great many *Elvan-courses:* on the sea-coast an extensive tract is covered by a mass of drifted sea-sand.

In the elevated range of granite there have been some workings, at Trenoweth and Copper-Hill, but they were inconsiderable, and have for some time been abandoned.

The slate series has an undulating surface of low hills, intersected by several small valleys which all run towards the north.

The general character of the rocks of this system is schistose, and the dip of their cleavage is towards the north and north-east. Near Hayle* they change from a light blue into a pale buff; at Angarrack the blue colour prevails, as it does also at *Herland* and *Relistian,* but in these Mines blue and white laminæ alternate, and the general inclination of the cleavage, which is still towards the north, is frequently curved

* "Around Hayle, a dark blue hornblende-rock prevails; it is prone to "decay, by which it becomes of a yellowish colour, and full of innumerable "joints and fissures." Dr. Boase, *Cornwall Geo. Trans.* iv. p. 347.

and contorted. At *Relistian** the slate contains numerous spheroidal concretions, some of them are compact, others schistose slate, and others are entirely of quartz.† In *Herland*,‡ at about 110 fathoms deep, there are numerous nodular masses of granite, which consist of a basis of felspar, with some quartz and a little mica; they are fine grained and decomposing. They vary in size, and whilst some are not larger than a hazel-nut, others are two or three feet in diameter. Both at *Relistian* and *Herland* they are entirely enveloped by the slate, and have no apparent connexion with each other; neither have the masses of granite in the latter any contact with the *lodes*, or with any of the small strings of quartz traversing the slate.

Between Angarrack and Nanpusker, near Trenawin, and at *Trevaskus* massive hornblende rocks occur. These consist almost entirely of felspar and hornblende, and sometimes, but rarely, they have a crystalline structure: usually, however, their aggregation is lamellar, with but few indistinct traces of slaty cleavage. The minerals are arranged in somewhat parallel, but small and irregular laminæ. The opportunities for examining their structure are, however, neither considerable nor numerous. At *Trevaskus* the greenstone is quarried for building purposes; and there I obtained some very good

* Table XXXVI. † "In Cornwall, the compact variety of chlorite-schist "near Relistian Mine exhibits this conglomerated structure; its nodules are "not globular, but flattened, and are composed of concentric layers, the outer "ones being softer and more chloritic, the central ones more compact and "crystalline." DR. BOASE, *Primary Geology*, p. 115. ‡ Table XXXIV.

specimens of asbestiform actynolite, and also of axinite, from an irregular vein which seemed connected, in a manner not very intelligible, with a cross-vein of quartz.

Elvan-courses abound in this district, but their directions are very various. At Hayle Foundry, and twice between that place and Hayle Copper-house, *elvan* appears; another occurs a little north of Saint Erth church. At *Wheal Alfred, Trevaskus, Herland* in two places, at Drannack, Bosoral, *Relistian, Parbola, Duffield* in three places, *Wheal Providence, Wheal Sarah,* south of *Wheal Strawberry (Wheal Julia),* and at Skues, *elvans* are seen. In general they bear about N.E. and S.W., and vary very much in dip and in breadth; but they are commonly several fathoms wide, and dip much less than the *lodes.* Most of them are composed of a basis of compact felspar, which here and there (at *Herland* for example) becomes quartzose; the imbedded minerals are felspar and quartz, sometimes in well-defined crystals, but often confused. Many of the *elvans* abound in schorl, and a few contain mica.

A considerable part of the *elvan-course* at *Relistian* has been taken away for the sake of the tin ore which it contained, and an open excavation from the surface to 39 fathoms deep attests its former productiveness. It bears about 16° S. of W., is nearly perpendicular, and is 11 fathoms wide; as the whole which contained tin ore is removed it is not now possible to ascertain the mode of arrangement of the metallic

mineral. In several spots, round pieces of the rock precisely similar in character to the contiguous mass, have been found firmly imbedded in the *elvan*.

In some parts the *elvan* of *Relistian* is a well-characterized felspar porphyry, in others it becomes quartzose, and it then contains copper and iron pyrites, and oxide of tin; it is then called the *South lode*, and the mass of round stones mixed with these minerals which occurred in one part of it was well known and has been often described.*

At *Parbola*† the *elvan-course* bears about 10° N. of W., and dips S. 40–60°, it is about 12 fathoms wide. Its basis is a compact fine grained felspar, containing some quartz and schorl; where it approaches the contiguous slate, it is generally of a very much finer texture than elsewhere. It has a very irregularly jointed structure and the crevices are filled with felspar clay.

The *elvan* is everywhere traversed by minute and innumerable veins and strings of tin ore which bear about 20° W. of S., and are usually parallel, but often intersect, both in dip and direction. Several of them occasionally unite and form a *bunch*, and afterwards separate again.‡ The joints of the rock traverse all, but displace none of them; and they all terminate at the slate which bounds the *elvan* on both sides. The

* Mr. Carne, Phil. Trans. for 1807, p. 298.

† In this mine I suffered a fracture of the knee joint, by the fall of a stone on me.

‡ They closely resemble the little veins of tin ore in the granite of *Carclaze*, and of copper ore in the slate at *Wheal Music*; and possibly, in some respects, the *Wherry Mine*, which is also in *elvan*.

slate, greenstone, and *elvan*,* are all traversed by joints which remarkably coincide with the directions of the *lodes;* and in the schistose varieties of the slate the joints are often filled with extremely thin plates of white quartz. Strings of quartz from the *lodes* often, as in *Herland*,† pass off between the laminæ of the slate, but the plates I have mentioned are never observed to do so.

There are two principal series of *lodes;* one of which bears about 25° S. of W., the other, the *Caunter lodes*, about 20° N. of W. The great prevalence of the latter forms one of the chief peculiarities of this district.

The dip of all the *lodes*, a very few excepted, is towards the south.

Another very striking character of the *lodes* in this district, which is very unusual elsewhere, is that they, as well as the contiguous rocks, alike contain large quantities of the globular concretions already noticed. The case of *Relistian* has been long known; but there are similar and equally curious phenomena in another *lode* in the same mine, discovered since Mr. Carne's publication,‡ and also in *Trevaskus* and *Herland.*

A cursory inspection reveals but little, a narrower scrutiny and the breaking of the rock, however, will in many cases discover that it consists of large numbers of spheroidal masses cemented together by a matrix, sometimes quartzose, but oftener slaty.

* The joints are often less regular in *elvan*, than in the contiguous rocks.
† Table XXXIV. ‡ Phil. Trans. 1807, p. 293.

These round stones are sometimes massive and at others schistose slate, and in one case in *Relistian* I have seen a piece of *elvan* so enclosed; whilst at *Trevaskus* globular lumps of copper pyrites are often surrounded by quartz, and in the *Badger lode* in *Herland*,* round masses of granite, slates, and *elvan*, are indiscriminately mixed and cemented together by a basis which is sometimes of felspar and quartz with a little mica,† and at others of quartzose slate, iron, and copper pyrites.

The *Badger lode* in *Herland*, the *South lode* in *Relistian*, *Trevaskus*, and *Duffield*, are the only localities yet known in the district where these spheroidal masses occur in the *lodes*: for they are generally seen in a layer of rock which cannot properly be called *the lode*, but which intervenes between the *lode* and the *country*, and is of an intermediate character.

It should be added that the granitic masses in the slate at *Herland*, and the round *elvan* stones in the *elvan-course* at *Relistian*, are far removed from any metalliferous deposit.

Copper pyrites is the most abundant mineral in the district; but vitreous copper ore, and the oxide of tin are also found in small quantities in most of the mines. At *Carnise*, *Godolphin*, and *Trevaskus*, however, they are the principal produce. At *Herland* large quantities of silver, in the state of

* A paper of my own; Edin. New Phil. Journal, XXII. p. 166.

† Mr. Edmonds, Cornwall Geo. Trans., III. p. 332.

ony has been found in great abundance
y at *Trevaskus;* the phosphate and arsenio-
of lead at *Wheal Alfred;* silver and some
as already mentioned at ***Herland;*** vitreous
in *Crenver;* and carbonate of lime finely
d, at *Binner Downs.*

Alfred, Herland, Wheal Abraham, Binner
Wheal Providence, Relistian, Wheal Kayle,
rawberry and ***Duffield,*** are situated near
its of hills; ***Trevaskus*** and ***Parbola,*** in
r rather elevated ground; ***Godolphin*** and
n valleys.

worgie there is a deposit of stream tin of
nt.

e eastern side of the Hayle river, and
on the Bristol Channel, there is a very
accumulation of sand, and in some parts
formation of sandstone by the cohesion

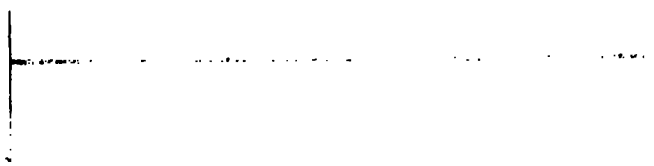
(*Pl. III. Fig. 7.*)

	Eastern Cross-course.	Flucan or Slide.	Little Flucan.	Eastern Cross-course.
N.E. 14°.....	*Lode heaved,* 9 ft. L.G.A.			

ns, II. p. 110, and Pl. III. Fig. 12.

AL PROVIDENCE, PARISH OF GWINEAR. *(Pl. IV. Fig. 5.)*

).	Size.	Appearance and Composition.	Appearance of Rock.	Caunte



BINNER DOWNS MINE, PARISH OF [illegible]

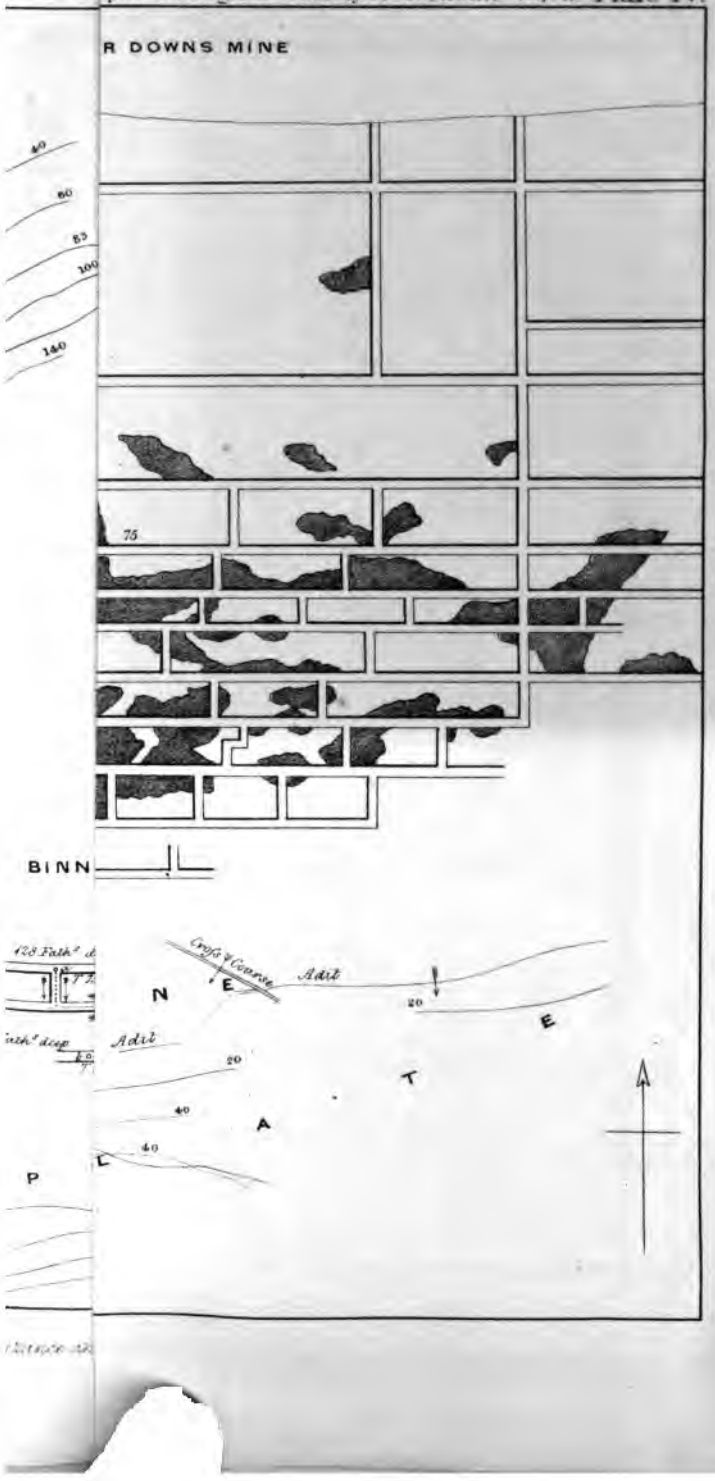
25° S. of W.	—	N. 56-63°	9 in.	Quartz, and large quantities of copper pyrites.	The joints bear N.W. and dip S.W., and the cleavage dips N. 20°.	
Hicks's or Caunter Lode, 17° N. of W.	86.	—	—	In three *branches* of crystallized quartz, at the separation from *North lode*, E.		
	96.	—	4 in.	Crystallized and granular quartz, at the separation from the *North lode*, W. This *lode* is only seen at its separation (E & W.) from the *North lode*—at the *South lode* it is unseen.		
Cross-course, 5° E. of N.	40.	W. 80°	10 in.	Crystalline quartz		*Lode* divided, but not *heaved*.
	50.	E.72-75°	—	Crystalline and granular quartz		Idem.
	60.	E.76–82°	4 to 6 inches.	Idem.		Idem.
	74.	P.	—	Crystalline quartz		Idem.
Flucan, 10° N. of W.	74.	P.	6 in.	Slaty clay		*Lode* divided, but not *heaved*.
	80.	E.72–83°	10 in.	Idem.		Idem.
Slide, 25° S. of W.	86.	N. 8-32°	4 in.	Slaty clay		*North & Hicks's lodes together. Lodes* divided, but not *thrown*.

* This is *Wheal Strawberry Lode*.

WHEAL STRAWBERRY, PARISH OF CROWAN.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
LODE,* 25° N. of W.	40.	S.79-82°	1.5 to 3 feet.	W. A vein of slaty clay on each *wall*, quartz, quartzose slate, slaty and felspar clay, copper, and iron pyrites, and black copper ore.	*Slate*, deep blue, thick lamellar; dip of cleavage N.E. 38°–S.W. 12°.
	—	S.80-86°	1.5 to 2 feet.	E. Granular quartz, earthy brown iron ore, iron, and copper pyrites.	
	50.	S.56-82°	0.5 to 2 feet.	E. Quartz, sometimes granular, blende, and copper pyrites.	Deep blue, thick lamellar, N.W. 18–24°.
	—	S.73-88°	—	W. A vein of blue slaty clay, N. *wall*, quartzose slate, quartz some places granular, copper, and iron pyrites.	Idem, N.E. 8°, in the joints a thin layer of green unctuous matter (? chlorite.)
	60.	S.72-81°	12 to 20 inches.	W. Quartz, in some places crystalline. Granular quartz, and masses of slate; lumps of copper and iron pyrites. A vein of slaty clay on N. *wall*.	Deep blue; dip S.E. 10–18°, a little contorted in some places.
	—	S.69-78°	1.5 to 2 feet.	E. Quartz, blende, iron and copper pyrites.	
	—	S.72-78°	2 feet.	E. N. *wall* many parallel veins of crystalline quartz, quartzose slate, and iron pyrites.	Deep blue, soft; dip S.E. 10°; in some places much curved and contorted.
	70.	S.72-83°	1.5 to 2 feet.	W. Quartz in some places granular, quartzose slate, copper, and iron pyrites.	Idem; S.E. 8°.
	—	S.97-82°	8 to 20 inches.	E. Vein of blue slaty clay, S. *wall* quartzose slate, quartz, with spots of copper, and iron pyrites.	Deep blue, very thick lamellar; dip N.W. 12–18°.
	79.	S.72-85°	1.5 to 2 feet.	A vein of copper pyrites on one *wall*, and of iron pyrites on the other, quartz between them.	Idem.

* This is the *Gooseberry lode* of *Binner Downs Mine*. Table XXXIX.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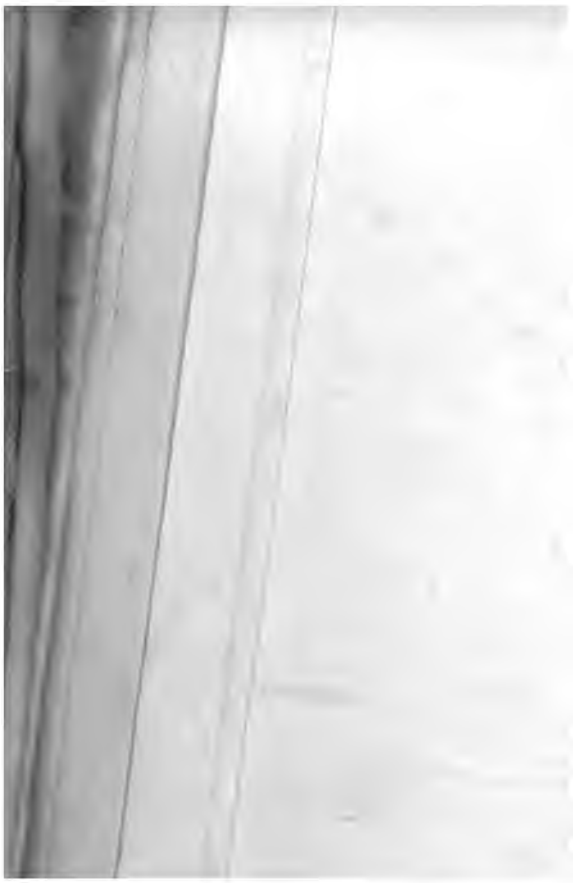

THE HELSTON DISTRICT,

Is bounded on the north by the rivulet which divides the parishes of Breage and Crowan, and by the granitic range of Wendron; on the east by an imaginary line from Wendron church to the sea; by the Mount's-Bay on the south; and on the west by another line drawn from Pra-sands, till it touches the Parish of Crowan.

It comprehends parts of the parishes of Germoe, Breage, and Wendron, the whole of Sithney, and of the town of Helston.

It contains all the granitic tract of Godolphin and Tregoning-hills, and a part of the great central mass of granite in the parishes of Sithney and Wendron; its other rocks are massive and schistose slates, and a few *elvan-courses.*

The granite of Godolphin-hill, though now and then coarse, is in general very fine grained and hard; and consists for the most part of a yellowish white and pale brown felspar, quartz, and dark mica, and abounds in radiating crystals of schorl. That of Tregoning-hill is chiefly talcose granite *(protogine)**

* "Tregonning Hill appears to consist almost entirely of a talcose granite, very "like the china-stone of St. Stephens: indeed some part of it is extensively "decomposed, and has been worked for china clay. This kind of granite "contains large beds composed almost entirely of granules of white quartz, "the interstices being occupied by a yellow granular talc. There are, however, "in this hill some beds of fine grained granite which have been quarried on a "great scale, as a building stone, more particularly for window-sells, lintels, "pillars, and other ornamental parts, for which purposes it is well adapted, as "it splits readily into long blocks and slabs; it is generally called Breage-"stone." Dr. Boase, *Cornwall Geo. Trans.* iv. p. 349.

"The talcose granite, or protogine, also possesses its quartzose varieties "under similar circumstances as the true or micaceous granite, and more par-

of an ordinary texture, its felspar crystals are ill defined; the talc is sometimes white, but often of a pale yellow passing into very light green; and the proportion of quartz is rather small.

On the eastern side and near the summit of the latter, it is extensively quarried for building; and on the western slope it is also here and there worked for *china-stone* which is exported to the Potteries.* Some *china-stone* is also obtained near *Wheal Trewavas*.

At Tresowes-moor between Tregoning-hill and Germoe church, an attempt has been made to procure *china-clay*, but it has been attended with such partial success as did not warrant its prosecution. The whole of this tract apparently consists of this disintegrated granite, as the rubbish lying about the deserted workings at *West Wheal Vor*, and near Germoe is nothing else.

The granite extends from a short distance west of Germoe church to *Carleen* mine (a part of *Wheal Vor*) on the east; and from Godolphin on the north, to the Mount's-Bay on the south. It occupies the coast from the eastern part of Pra-sands to the little cove at Trequean, with the exception of a small patch of slate at Rinsey.†

" ticularly that kind which results from the disappearance of the felspar; and " is a granular compound, of a greenish colour. It is common in the china- " stone quarries in the central district, where, however, it is generally associated " with shorl; and it projects on the side of Tregonning Hill, in the form of " tors, or perhaps, rather, of boulders or transported masses."

DR. BOASE, *Treatise on Primary Geology*, p. 19.

* The china-stone quarries are held, and worked, by some of the Staffordshire earthenware manufacturers.

† " Immediately under Rinsey a patch of felspar slate lies on the side of the

The joints are extremely well shown, but their directions are by no means regular. Their most common bearing is about 20° E. of N., but another system bears about 20° W. of N., and a third nearly N.W.

There is a very distinct *bedding* of the rock,* which seems in its dip to have some coincidence with the external form of the hill; thus, in the quarries on the east, it dips E.; in the *china-stone* quarries on the west, it dips W.; and where the hill declines towards the south, as well as at *Wheal Trewavas*, where the slope towards the cliff has an inclination in a similar direction, the *bedding* appears to have a southerly dip.

The granite of the Wendron and Crowan patch is of a very different character. As much of it as comes within the limits of this district, for instance, that about *Wheal Trannack* and *Wheal Trumpet* is coarse grained, and consists of a basis of compact felspar, either white, greenish, or pale buff,

" granite, as at Tremearne; and exhibits similar phenomena: it extends round " the head-land as far as the village of Pra, where the granite projects in large " scattered masses." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 354.

" About half way between (Trewavas Head) and the east side of Pra-sands, " a patch of slate occupies the base of the cliffs for about 300 feet.

" On descending during low water, to the margin of the sea, we find all the " intermediate space occupied by nearly horizontal beds of killas which are " soft, micaceous, and in a more advanced stage of decomposition than is gene- " rally exhibited in similar situations. At their western extremity they are " seen reposing on the granite, though not adhering to it; but at the eastern " side of the cove they are at once cut off by a projecting mound of granite, in " such a manner, that the line of demarcation may be traced in a direction " perpendicular to the horizon, from the base of the cliffs till it is lost in the " alluvial cap at the top." PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. pp. 111-114.

* " In one part of Tregoning Hill the Granite appears to be regularly " stratified." MR. CARNE, *Cornwall Geo. Trans.* II. p. 94,—note.

with quartz, and dark mica, and enclosing numerous large crystals of white or pale brown felspar.* In many places it contains beds and veins of a finer grained variety, but of similar composition.

The junctions of granite and slate, and the veins of the former traversing the latter, are as remarkable and as instructive as any of the numerous examples which this County affords. Many of these have been so often described, that I shall merely quote the remarks of observers of great eminence, with whom I entirely concur.†

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* "At Trumpet tin mine, a little south of Wendron, the granite is very "crystalline; its white felspar is in excess, and is generally in the form of "large porphyritic crystals. One kind of this granite, though quite hard and "unchanged when brought to the surface, becomes in two or three years quite "disintegrated: and indeed adjoining the *lode*, it is frequently in this condition "to a considerable depth." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 332.

† So long ago as the year 1792, Mr. John Tallack, speaking of this district, said "the cliffs were wonderfully compounded, numerous beds of growan and "killas of all dimensions, from 10 feet to an inch, alternating with each other. "* * * * * They are not elvan, but real growan and killas. The beds dip "about 1 foot in 20 towards the south."

MR. HAWKINS, *Cornwall Geo. Trans.* II. p. 380.

"About a quarter of a mile east of Trewavas point the cliffs are in an "unusually ruinous state, and a small brook has excavated a passage which "affords an easy descent to the waters edge. On reaching the beach we first "found the killas rocks intersected by many contemporaneous veins of quartz. "Not many feet farther west we were surprized to observe an appearance of "alternation between the slate, on which we were advancing, and several thin "beds of granite. One, more especially, which towards its southern extremity "was lost under the waters, preserved its thickness and conformity to the "laminæ of the schist for more than 100 feet. But its true nature was easily "determined in the other direction; for it gave out several smaller veins, then "cut obliquely through the laminæ of slate, and at length contracted its "dimensions, started entirely from its previous direction, and ran in a flickering "line across the perpendicular cliffs. This vein is in no part more than 2 feet "wide; yet it may be traced, from the edge of the water to its termination in "the cliff nearly 400 feet. In the cliffs farther west there are several granitic "veins, which would be considered of no great interest, if they had not been "intersected by two other veins of a different character, which must be classed "either with the metalliferous lodes or the cross-courses of the County. One "of them ranges nearly in the magnetic meridian, is about one foot and a half

Near low water mark on the eastern side of Prasands a very small patch of slate rises through the

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" wide, and underlies east, two feet in a fathom. The other underlies in an " *opposite* direction. They both contain quartz, oxide of iron, and apparently, " some fragments of clay-slate. At the time of their formation, the mineral " masses which they traverse must have undergone a considerable disturbance; " for the broken ends of the schistose beds and granite veins where they pass, " are distinctly heaved from their original position.

" Beyond this point, the whole base of the cliffs is, for some extent, covered " with huge fragments of veins which have been washed out of the decomposing " killas. One of them appears to have been more than 10 feet thick, and many " others are nearly of the same dimensions. They are of a brilliant white " colour, and fine granular texture in their general mass; but occasionally " contain within themselves parallel veins of a very contrary character, com- " posed of large crystals of quartz and felspar. In some instances these " crystals are 6 or 8 inches long; singularly interlaced; and proved to be of " contemporaneous origin, by the long spiculæ of schorl which pass, without " interruption, through both quartz and felspar. To the west of these extra- " ordinary ruins we advanced along a bed of granite, 1 foot thick and about 40 " feet in length and breadth, which passes under the cliff, and appears to alter- " nate with the slate. Every portion of the neighbouring strand, would at first " sight, appear to confirm this supposition. But all such beds are but examples " of granite veins, the direction of which nearly coincides with the cleavage of " the slate; their true nature being always exposed in the cliffs where the " section allows a sufficiently extended examination.

" Still farther west we found the rocks beautifully intersected by granitic " veins; the higher parts being traversed by innumerable ramifications, while " the lower part is cut through by one well-defined vein about a foot thick, " which after keeping nearly in the direction of the beds of slate for about 60 " feet, suddenly starts off at right angles to its former direction and rises *up* to " the top of the cliff. The whole system of veins here described afterwards " unites in one trunk, which traverses a projecting ledge of rock and descends " obliquely into a mass of granite which forms the eastern side of the entrance " into a singular natural cavern. Both sides of its entrance are of granite; but " the roof is formed by undisturbed beds of killas. The granitic masses, how- " ever, soon contract their dimensions and wedge out into the schistose rocks, " which form both the roof and walls of the cavern about 50 feet from its " commencement.

" Immediately beyond the entrance of this cavern we remarked a mass of " most imposing character and dimensions. It seemed to be the root of those " gigantic veins which rise from this point and ascend, in broad white lines, " towards that part of the cliff which reposes immediately on the central granite.

" Near this place we observed many large angular masses, resembling splinters " of clay-slate, imbedded in the middle of the veins. Whatever may have been " their origin, they certainly very much resemble fragments torn off from the " parent rock by rude mechanical force, and afterwards entangled in the veins. " And such a conjecture seems confirmed by remarking, that the ragged edges " of the imbedded fragments in some instances appear to tally with each other.

sand; it is of a mottled greyish colour, is very micaceous, intersected by many veins of quartz, and

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"From the very point which is marked by so much confusion, two large veins "separated by a lancet-shaped mass of slate, rise towards the west at an angle "of about 15°. Within a few feet of the other two, a third vein starts out "nearly at the same angle, and proceeds in the same direction. These three "veins are throughout nearly of the same thickness, viz. each about 5 feet. "The highest, at some distance from its base, begins to ascend more rapidly, "and is lost in the alluvial soil at the summit. The other two preserve their "course, without being much deflected, for some hundred feet, and from the "place where we first remarked them, disappear behind a projecting part of the "cliff. On turning this projecting ledge we suddenly reached a recess, the "lower part of which was filled with the ruins from the higher part of the "overhanging rocks. The western side of this recess is composed of killas "intersected by some small granitic veins. A protruding mass of granite forms "the base of the eastern side to the height of 25 or 30 feet. It is of very "singular outline, yet does not appear to have thrown the slaty laminæ reposing "on it out of their usual direction.

"The mound of rubbish in the recess enabled us to ascend more than half "way up the cliff and trace the two large veins before mentioned into an "enormous bunch of granite, which here reposes on the top of the cliff, and is "supported by undisturbed beds of slate; the line of demarcation being nearly "horizontal, and at an elevation of 60 or 70 feet above the level of the beach. "The denuded face of this bunch of granite is 30 or 40 feet thick, and, if a "section were made farther from the cliffs, would probably be much more "considerable: for the ground rises rapidly to the north, and it is impossible "even to form a conjecture, how far the cap of granite may extend in that "direction.

"Two or three veins appear to take their origin from this anamolous overlying "mass. One spreads out in minute ramifications towards the part of the cliff "which abuts against Trewavas Point, at the termination of the killas in that "direction. Two others descend obliquely, and are lost behind the large mound "of rubbish before mentioned.

"Such are the complicated phenomena exhibited at this junction."

PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p. 117, &c.

"The granitic veins are not, in composition, like those of Dolcoath; but "partake more of the prevailing variety of the adjoining hill, which is a con- "tinuation of that of Tregonning. The small veins are generally harder than "the large ones, owing to the predominance of granules of quartz intimately "intermixed with minute particles of felspar and talc; sometimes shorl is "present, and then this granitic stone is much harder than the preceding. The "large veins consist of a fine grained talcose granite which becomes yellowish "on decomposition; it is also traversed by short irregular veins, in which the "felspar, quartz, and talc, occur in large crystallized groups, the first mineral in "particular being well defined. The middle part of these veins is most granitic, "and that of the largest veins cannot be distinguished from the granite of the "main mass." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 353.

See also, Mr. Moyle, Annals of Philosophy, VI. (1823) p. 90, Pl. XXI. fig. 1-2-3-4-5; and Mr. Thomas, Mining Review, No. IX. (1837) p. 30, Pl. 1.

dips towards the south. Many small granite veins also traverse it: one of these is very coarse grained and porphyritic in the middle, but at the sides passes into a very fine grained felspar rock.

Farther eastward a compact rock of a greenish hue, reposes on the granite, and the transition from one to the other is very gradual. Elevated portions of the granite protrude through it in many places; and in others the slaty covering has been removed by the action of the waves. Near the junction the granite consists, almost entirely, of a very fine grained basis of felspar and quartz, containing numerous and very large crystals of pale buff coloured felspar, and a little schorl.

The joints, both in the granite and slate, are very well displayed: they are prolonged without interruption through both rocks, and even through the granite veins. One series of them bears about 35° W. of N., to which the course of the granite veins in some measure conforms; another runs about 20° S. of W.; they are, however, all curved, and frequently vary in their directions.

In *Carleen Mine* the slate rock which is continued to the east of Helston, joins the granite of Tregoning hill.* Their junction is simply a very gradual transition from one into the other: the lamellar dark blue slate, passes into a crystalline quartzose rock, and this into a pale buff felspar, which leads to

* "The rocks, next the granite of Tregonning, are precisely of the same "description as those at Dolcoath and Cook's Kitchen: viz. alternating beds of "massive and lamellar rocks. * * * The latter * * like the massive variety, "is principally composed of compact-felspar."

DR. BOASE, *Cornwall Geo. Trans.* IV. p. 350.

the regular granite. The joints are numerous; one system of which is parallel to the *lode*, and another bears about N. and S.

At a distance from the granite, the slate is traversed by many granitic veins which do not conform either to its cleavage, or to the joints. The appearances are by no means similar on either side of *Carleen lode*, for the granite veins are much more numerous and distinct on the N. than on the S.

In *Great-work** the line of junction is very distinct, but as its dip is jagged and irregular, it occasions the granite to overlie the slate in two

* " This mine was formerly called *Godolphin Ball*. " Cette mine est la plus " étendue qu'il y ait dans la province de Cornouaille; son exploitation est aussi " des plus anciennes: elle se trouve placée dans un pays presque plat, entre " deux petites montagnes, dont l'une a son exposition au nord & l'autre au sud. " La direction des filons est toujours de l'*est* à l'*ouest* comme dans toutes les " mines de la province, & leur inclinaison au nord d'environ 70 degrés.

" Cette mine exploitée jusqu'à la profondeur de 90 toises, ne l'étoit alors " que sur une petite étendue; mais on reprenoit chaque jour les anciens " ouvrages. On compte cinq filons paralleles sur 50 à 60 toises de largeur, " mais qui ne sont point travaillés également; ils l'ont été seulement à dif- " férentes hauteurs lorsqu'ils ont produit du minérai: le filon principal est le " seul qui ait été exploité en entier & qui le soit encore. Ces filons sont " renfermés dans un granite à gros grains trés-dur. Il n'en est pas ici comme " je l'ai observé ailleurs, sur-tout en Saxe & en Bohême; l'étain ne s'y trouve " jamais réuni & confondu, mais dans une espece de rocher bleuâtre, qui paroît " être la matrice générale du plus grand nombre des mines d'étain de " Cornouaille. Celui qui joint le *mur* du filon & que l'on nomme le *guide*, est " un quartz mêlé quelquefois à du mica; le filon consiste lui-même en un " quartz fort dur, d'un blanc bleuâtre réuni à ce rocher qui contient le minérai, " il y est aussi crystallisé en exagone; le minérai s'y trouve presque toujours " en petits grains semblables à des grenats & parsemé de mica.

" Ce filon depuis 2 jusq'à 5 pieds de largeur, est quelquefois divisé par des " parties de granite qui viennent du *toit* ou du *mur*, & que j'ai dit que l'on " nommoit *horse;* il produit assez souvent du très-bon minérai jaune de cuivre."

JARS, *Voyages Métallurgiques*, III. p. 194. (1765.)

" At the lowest part of the hollow curve between Godolphin and Tregonning " Hills, the rock near the surface has a schistose structure, separating into " thick laminæ, which, on the cross-fracture, are marked by lines parallel " thereto: this rock is much decayed, and stained red by oxide of iron; it is " probably composed of granular felspar, interlaminated with mica."

DR. BOASE, *Cornwall Geo. Trans.* IV. p. 349.

places; yet as it is in these situations very highly inclined, the overlapping is of but small extent.

At *Wheal Trannack* a mass of schorl-rock at one spot intervenes between the granite and slate; in another a massive micaceous rock interlies the granite; whilst at other places veins and beds of granite project from the main body of that rock, into the slate.

All the slate of this mining district is in the immediate vicinity of the granite, and most of it consists of varieties of felspar, with mica and hornblende; these are generally thick lamellar with an irregular cleavage, and are often of a deep blue colour.* In contact with the granite, it has been already seen, they are frequently massive and very felspathic, but mica is sometimes abundant.

At a distance from the granite a more decidedly schistose character prevails in the slates, still they are commonly of a deep blue colour which becomes reddish brown on decomposition, and contain many veins of quartz.†

The best known *elvan-course* in this district is at Pra-sands.‡ It is about 12 fathoms wide, bears 35°

* "At about a quarter of a mile south of Breage church, in a schist quarry, "there are three parallel granite veins, of the same description as those at "Tremearne, inclining in the same direction. The middle vein of these is about "twenty inches wide; about four feet above it is the upper vein, about four to "five inches wide, and about four feet under it is the lower vein, about two "inches wide." Mr. Thomas, *Mining Review*, No. ix. p. 30. (1837.)

† "The eastern side of Looe Pool, about two miles from Helston, is barren; "and is formed of slate which becomes red on decomposing, and abounds in "quartz veins." Dr. Boase, *Cornwall Geo. Trans.* iv. p. 347.

‡ "A very beautiful elvan, more than 40 feet wide, appears below the high-"water mark, at the western extremity of Pra-sands, near the perpendicular

W. of N. and dips N.E. 40–50°. It has a basis of compact felspar and quartz, and contains in its centre large porphyritic crystals of pale pink coloured felspar, but towards the sides is mostly compact felspar. The slate in contact is very quartzose, and deep blue, and dips W.; some beds of it have a fine silky lustre, and others are compact and crystalline. The same joints traverse both the slate and the *elvan*.

At *Wheal Vor* there are two *elvan-courses*;* both bear about 25° S. of W., and dip N.; the northern about 60-70°, the southern 40–50°,—the former is 2 feet wide, the latter about 8 fathoms. They are

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" cliffs which form Pedn-du-point. It ranges nearly north-west and south-
" east, and seems conformable to the killas beds, which are neither disturbed
" in their position, nor altered in their texture at the junction. The exterior
" parts of this elvan pass into the third variety (hornstone porphyry), but the
" central mass is a porphyritic granite."

PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p. 129.

" In a little recess, not far from Pengersick, the hornblende slate is inter-
" sected by an *elvan-course*, which lies west of north, and east of south, dipping
" N.E., at an angle of 45°. This *elvan* is a felspar porphyry, which in the
" middle resembles a coarse porphyritic granite, the crystals of which are flesh-
" coloured :—next the slate it is composed almost entirely of compact-felspar ;
" and the slate itself, in immediate contact with the latter, is very much inter-
" mixed with quartz." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 354; and *Treatise on Primary Geology*, p. 57, fig. 3.

* " In the eastern part of Huel Vor tin mine, in the parish of Breage, there
" are two elvan-courses. The northern course, which is the largest, is 20 feet
" wide, bears north-east and south-west, and underlies north nine feet in a
" fathom in depth. The lode which underlies north only a foot and a half, was
" productive in the killas, but much more so in the elvan. In the former it was
" two feet wide, but in the latter it increased to five feet, and in some parts
" branched through the elvan in such a manner as to impregnate the whole of
" it with tin, and to induce the workmen to take it away even for 20 feet in
" breadth.

" The lode is still in the elvan. Near the surface, this elvan appears to
" consist of decomposed felspar and quartz, a little deeper hornstone appears.
" In the deepest part of the south elvan, the hornstone is compact, and in some
" instances, slaty." MR. CARNE, *Cornwall Geo. Trans.* I. p. 102.—Ibid. II. p. 83.

My observations, which were more than once repeated, on the spot, do not, by any means, accord with Mr. Carne's description.

alike composed of a fine grained mixture of felspar and quartz, with a little schorl in some spots, and a few crystals of pale buff felspar. The *lode* has been productive of tin-ore in them both.

The prevailing directions of the veins are from 15° to 35° S. of W. and their general inclination is towards the north, but with some exceptions.*

Cross-courses are not numerous in the eastern part of the district, but in the western there are several, and some of the *heaves* are considerable. The principal cross-course of the neighbourhood is seen in the east of *Godolphin*,† whence it passes through *Polladras Downs*, and between *Carleen* and the other part of *Wheal Vor*; *heaving* some distance in both.

The chief mineral product of this district is tin ore, which principally occurs in *lodes*, as at *Wheal Vor*,‡ *Polladras Downs*, *Great Work*, *Wheal Trumpet*, &c: but it has also been found in irregular patches, and even disseminated through the granite at Raggy-rowal,§ on the eastern side of Tregoning-hill;|| and in a somewhat similar manner sprinkled

* *Wheal Trewavas lodes* bear 25-40° N. of W.

† Many mine agents, and miners of much experience, maintain that this *cross-course* takes a N.W. direction in *Godolphin*, and becomes one of the *lodes* in that mine.

‡ The present working of *Wheal Vor* has been continued about 18 years, and in that time about £1,240,000 worth of tin has been raised, of which I believe that more than £100,000 has been profit to the adventurers.

§ Probably this is the spot mentioned by Mr. Hawkins under the name of "Huel grouan in the parish of Breage." *Cornwall Geo. Trans.* II. p. 31.

|| Many joints in the granite, near this spot, are deeply striated; and present smooth polished surfaces which closely resemble *slickensides*, in every respect but that of metallic lustre.

through the southern *elvan* in *Wheal Vor*. Locally these irregular deposits are called *Pedn-cairns*.

It is not unworthy of notice that the enormous riches of *Wheal Vor* have been found in the slate, and scarcely a particle of tin-ore has occurred in the same *lode* in the granite; the *Great Work* on the contrary is profitable in the granite only,* and its *lode* becomes unproductive in the slate. *Wheal Trumpet and Wheal Ann* have also afforded large quantities of tin ore which were wholly in granite.

Copper-ore has been found both in granite and in slate at *Wheal Trannack*, in granite at *Wheal Trewavas*, and in small quantities in granite at *Great Work*, and in slate at *Wheal Vor*.

No bunch of ore, whether of tin or copper, inclines towards the main body of the granite, but always in a contrary direction. Thus, the deepest productive parts of *Wheal Vor*, *Great Work*, and *Wheal Trewavas*, are eastward; whilst in *Wheal Trumpet* and *Wheal Ann* they dip towards the west.

Wheal Penrose, east of Porthleven, has for many years been occasionally worked in search of lead ores; but, I believe, the returns have never been sufficient to reimburse the outlay.†

Close to the rough and difficult foot-paths which lead to the granite veins in Tremearne cliff, there are patches of granite and slate pebbles; the former are

* The talcose granite of Tregoning-hill does not extend so far north as *Great Work*.

† At this time *Wheal Penrose* is worked by a company of London speculators, whose agents have refused me permission to inspect the Geological characters of the mine.

most abundant, and are from the size of a nut to a foot or more in diameter: these beds repose on the slate about 14 feet above the present beach, but eastward rise to the top of the cliff, about 20 or 30 feet. At the western part of Pra-sands, and about 6 feet above the beach, there is a bed of granite, *elvan*, and slate pebbles, which for some distance is covered by a very high bank of rubbish,—the *debris* of the adjacent rocks; and on the eastern side of the cove there is a great accumulation of sea sand. At *Wheal Trewavas*, where the rock is wholly granite, it is covered by a thick bed of transported fragments of micaceous slate.

The action of the sea throws up a natural embankment of sand and shingle, which retains the drainage of the country, and forms the only extensive natural accumulation of fresh water in the west of Cornwall,—the Loe Pool.

The low-grounds are often submerged by its rise after heavy rains, and the *bar* is then cut through, with several antiquated formalities. But the natural causes by which it was formed, soon restore its original dimensions.

The valley running below Breage church-town to Porthleven, and also that from Helston to the Loe Pool, have been *streamed* for tin; formerly they may have been productive, but of late years the advantage derived has been inconsiderable.

The wild and romantic character of the coast is inferior to nothing of the kind in Cornwall; and *Wheal Trewavas* which has its engines perched on

the cliffs, and its workings beneath the sea,* is quite as picturesque as *Botallack* or *Levant* in the *St. Just district.*

The uniform barrenness of Tregoning, Godolphin, and the hills of Wendron is scarcely relieved by a few ill-rewarded attempts at cultivation. The valleys, however, are fertile, and the low-lands are in some places rich and well wooded.

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* In one part of the mine there is a very large quantity of water, which is excessively salt.

GREAT WORK MINE, PARISHES OF GERMOE AND BREAGE.

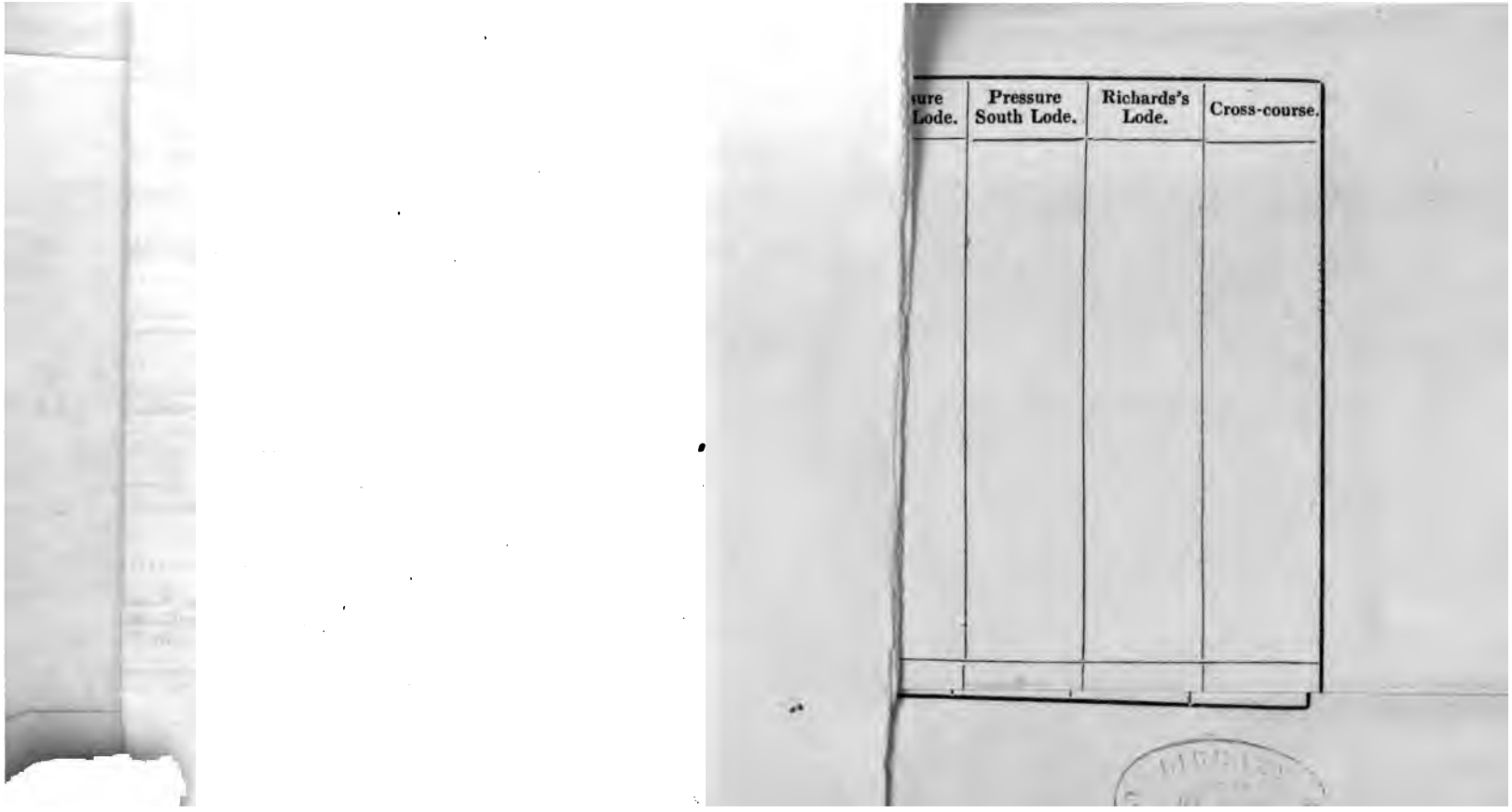
Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Cross-course.	East Flucan.
WHEAL BREAGE LODE, 30° W. of S.	62.	W. 68-74°	1.5 ft.	Crystalline quartz, dark chlorite, and oxide of tin.	The *granite* is friable and *overlies the slate*, at an angle of 80-82° S. W. Slate; cleavage dip N.E. 9-12°, thick lamellar, dark green.		
	[illegible]	N.W. 73-84°	[illegible] 5 feet.	Quartz, and felspar, with oxide of tin and good bunches of black copper ore.	Quartzose, hard, pale buff felspar in porphyritic crystals; joints N.W. & S.E. and dip N.E. 65°.		
	142.	N.W. 76-84°	3 to 3.5 ft.	Quartz, brown iron ore, felspar clay, and a little black copper ore.			
CROSS-COURSE, 5° E. of N.	112.	W. 84°	4 in.	Disintegrated granite.			
	122.	—	—	Idem.			
	132.	—	—	Idem.			
EAST FLUCAN, 30° N. of W.	82.	N. 64°	1 foot.	Disintegrated granite.			
	90.	N.82-84°	6 in.	Idem, fine grained, and very micaceous.			
	98.	N. 82°	1 foot.	A vein of quartz and chlorite, with another of granite, with much felspar clay.			
	122.	N. 74°	2 feet.	Crystalline quartz, disintegrated granite, and felspar clay in large quantities.			

WHEAL VOR, PARISH OF BREAGE. (Pl. V. Fig. 8.)

	85.	—	2.5 ft.	*Idem.*		lode a little E.	
	95.	—	1.5 ft.	Idem		*Lode heaved*	
	60.	W. 54-70°	4 feet.	Idem			4.5 fms. —
	85.	W. 44-58°	3 feet.	Idem As this *cross-course* descends, it divides at 140 fms. deep.		*Lode heaved,* 1 foot L.S.A. The *lode* is very irregular between the two veins of the *cross-course.*	
Western part of the Eastern Cross-course.	140.	W. 54-60°	4 feet.	Veins of crystalline quartz, with felspar clay.	Deep blue.		
	150.	W. 60-70°	5 feet.	Idem	Idem	*Lode heaved,* 5 fms. L.S.A.	
	170.	W. 60-64°	3 fms.	Quartz, and slate, irregularly mixed.	Idem	5 fms. —	
Eastern part of the Eastern Cross-course,	140.	W. 54°	6 in.	Slate, and slaty clay.			
	150.	—	10 feet.	Idem. A vein separates from this, as it descends.		*Lode heaved,* 1,5 fms. L.S.A	
	170.	W. 50-60°	5 feet.	Crystalline quartz, and earthy red iron ore.		5 feet —	
	180.	W. 80°	8 feet.	Crystalline quartz, slate, earthy red iron ore, and iron pyrites.		7 feet —	

* *Carleen* is the western part of *Wheal Vor*, and is worked on the same *lode.*

† A large *cross-course* divides one from the other, and *heaves* the *lode* about 4 fathoms R. This is the same which is seen in *Polladras Downs;* but it is not cut through in *Wheal Vor.*


ure Lode.
Pressure South Lode.
Richards's Lode.
Cross-course.

Dir. of vein.	This.					
LODE,* 15° S. of W.	122.	N. 74–84°	14 in.	*Walls* smooth, granite in regular blocks, with a few small spots of oxide of tin.	*Granite*, basis of compact felspar, much mica, and large porphyritic crystals of felspar.	
	132.	N.72°–P	1 in.	Disintegrated granite, and brown iron ore.	Idem.	
	—	—	4 in.	Idem.	Idem, soon decomposing after being opened.	
	—	—	1.5 ft.	Oxide of tin, quartz, and green felspar.		
	142.	N. 72–84°	4 to 6 inches.	Brown iron ore, green felspar, and mica.	Porphyritic, basis dark brown felspar, and quartz, dark mica, and large white crystals of felspar; generally dipping W.	
				Divided into two *veins*.		
	—	N. 74°	—	N. vein. Disintegrated granite, with schorl.		
	—	S. 72°	—	S. vein. Idem.		
				The joints traverse both *lode* and *country*; but they are not usually *kindly* when well shown; in the N. *wall* they sometimes accompany oxide of tin in the *lode*.		
CROSS-COURSE, 5° E. of N.	122.	P.	1 foot.	Disintegrated granite on each *wall*; a vein of quartz in middle.	.....	*Lode heaved*, 6 in. L., G.A.

* This is the eastern extension of *Wheal Trumpet lode*.

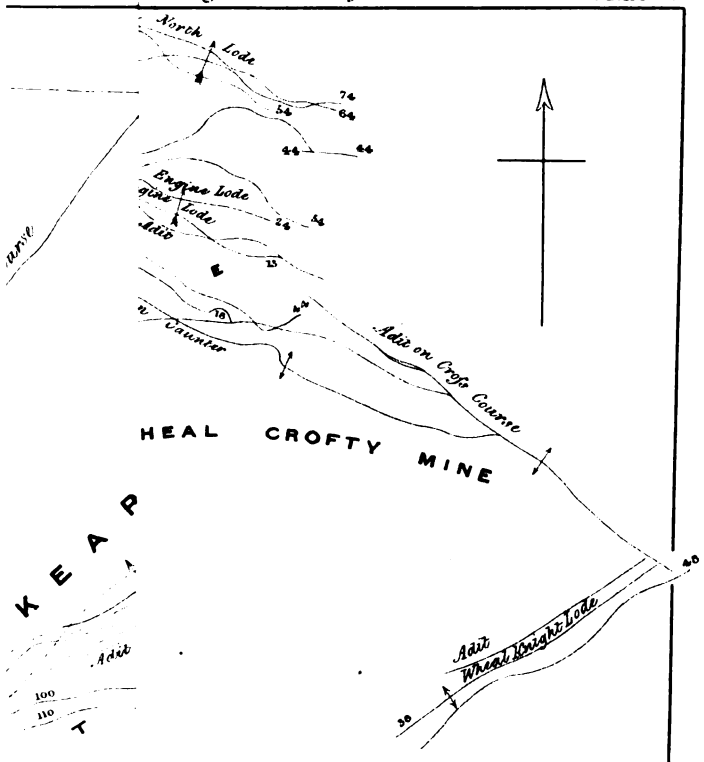


Fig 1.

PLAN OF MINE

OLPHIN M

Pryssure Lode

A

Fig 6.

WHEAL CROFTY MINE

SECTION

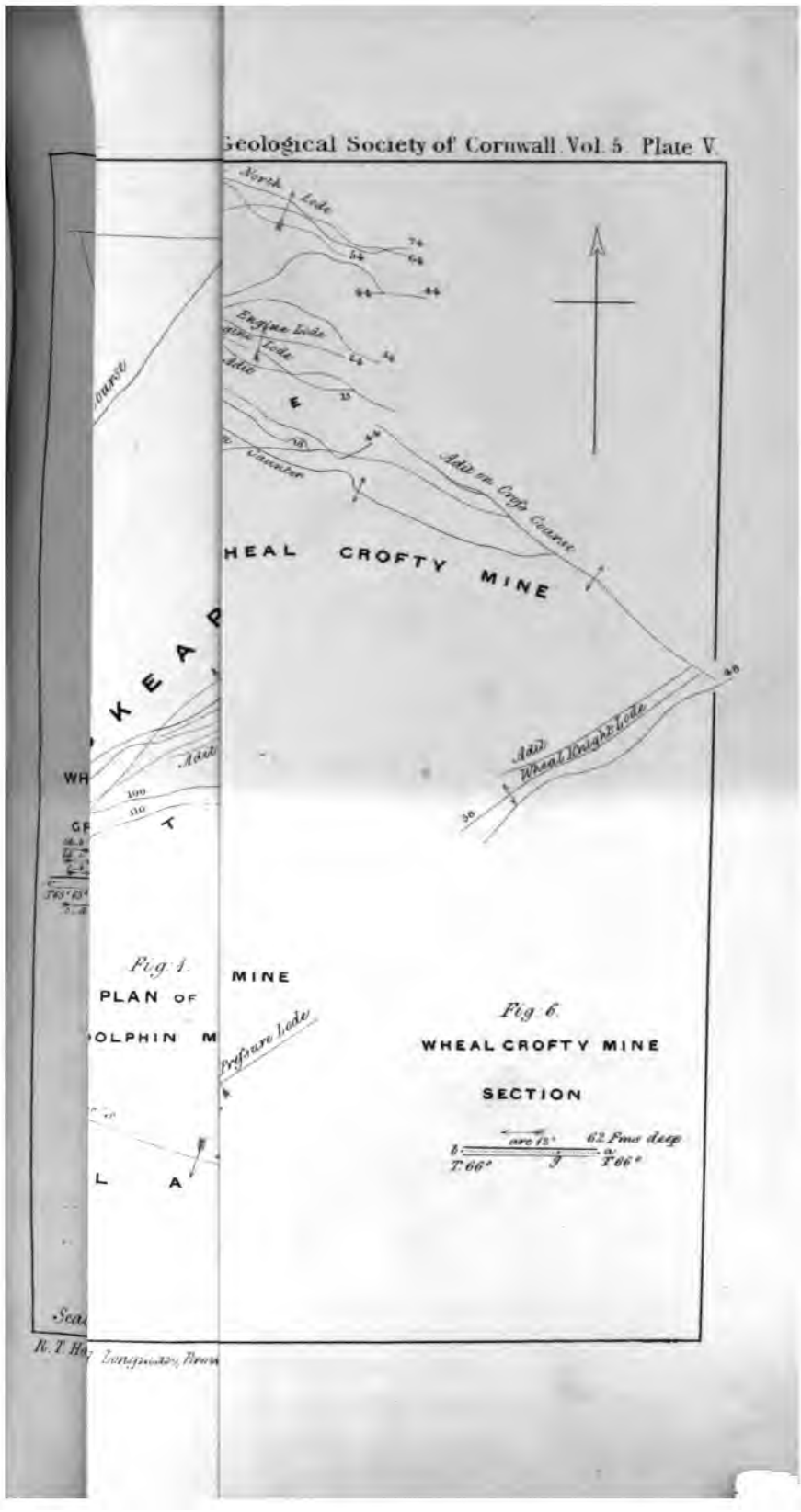
Lithographic Press

WHEAL ANN, PARISH OF [illegible]

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Lode.
LODE,* 15° S. of W.	122.	N. 74–84°	14 in.	*Walls* smooth, granite in regular blocks, with a few small spots of oxide of tin.	*Granite*, basis of compact felspar, much mica, and large porphyritic crystals of felspar.	
	132.	N.72°–P	1 in.	Disintegrated granite, and brown iron ore.	Idem.	
	—	—	4 in.	Idem.	Idem, soon decomposing after being opened.	
	—	—	1.5 ft.	Oxide of tin, quartz, and green felspar.		
	142.	N. 72–84°	4 to 6 inches.	Brown iron ore, green felspar, and mica.	Porphyritic, basis dark brown felspar, and quartz, dark mica, and large white crystals of felspar; generally dipping W.	
				Divided into two *veins*.		
	—	N.74°	—	N. vein. Disintegrated granite, with schorl.		
	—	S. 72°	—	S. vein. Idem.		
				The joints traverse both *lode* and *country*; but they are not usually *kindly* when well shown; in the N. *wall* they sometimes accompany oxide of tin in the *lode*.		
CROSS-COURSE, 5° E. of N.	122.	P.	1 foot.	Disintegrated granite on each *wall*; a vein of quartz in middle.	.....	*Lode heaved*, 6 in. L., G.A.

* This is the eastern extension of *Wheal Trumpet lode*.

Table XLVIII.


North Lode
Engine Lode
Adit
Adit on Crofts Course
HEAL CROFTY MINE
Adit
Wheal Dright Lode
Fig. 4.
PLAN OF
MINE
Pryor Lode
Fig. 6.
WHEAL CROFTY MINE
SECTION
62 Fms deep
T. 66°
T. 66°

THE CAMBORNE AND ILLOGAN DISTRICT,

Comprizes such portions of the Parishes of Camborne and Illogan as are bounded on the east by the valley which divides Illogan from Redruth; on the south by a line passing through the ridges of Cairn Brea, Carnarthen Cairn, Cairn Entral, and Camborne Beacon Hill; on the west by a line drawn from Camborne Beacon to about half a mile north of Camborne church; and on the north by a line parallel to the highway from Camborne to Redruth.

Mr. Thomas's excellent map, sections and report,* have given us a knowledge of this, and of a district next to be described, probably unequalled in precision by that afforded by any publication on the metalliferous deposits in any part of the Kingdom.

The rocks of the district consist of an elevated range of granitic hills on the south, covered on their northern slope by varieties of the slate formation; and intersected by several *elvan-courses*, and numerous *lodes* and *cross-courses*.

The granite of Cairn Brea, and of the adjacent hills westward, is separated from Cairn Kye and the contiguous southern range of Illogan, Wendron, and Crowan, by a mass of slate which extends from *Wheal Buller*, along the southern slope of Cairn Brea,† not far from its summit, and westward

* "Report on a Survey of the Mining District of Cornwall, from Chacewater to Camborne," with a Geological Map and Sections. By Richard Thomas Surveyor, and Civil Engineer. (1819).

† "About 80 fathoms south-east of the eastern part of the summit of Cairn

through Cairn Kye village, Bisleak and *Condurrow*,* to Ramsgate near Pendarves.†

This interposed mass of slate is very schistose, and mostly of a dark reddish brown colour, often very micaceous, and much decomposed.

The granite is rather coarse grained, and has usually a basis of white felspar, quartz, and dark mica, including moderately large crystals of white felspar often badly defined: but there are also large patches, and numerous veins and beds of a fine grained granite which generally contains schorl.

The alternations and mixtures of granite and slate, at and near their junctions, in *Cook's Kitchen*‡ and

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" Brea; and about 14 fathoms under its level, on the declivity of a hill, is a " tin mine, which has been sunk about 20 fathoms; but no granite appears,— " the ground being killas." MR. THOMAS, " *Report*," p. 10.

* I am informed by Captain Petherick that at *West Dolcoath*, a small mine recently opened south of Camborne, the slate and granite appear in parallel layers or beds, which are vertical or highly inclined.

† The separation of the granite of Cairn Brea, and the northern range from that of Cairn Kye, and the other hills to the south, by a mass of slate, was first discovered by Mr. Thomas. " The granite formation is intersected by the slate, " so as to divide two small portions from the remainder; and I distinguish " these as the Carn Brea range and the Carn Marth range. The former extends " from Redruth church westward to Pendarves, about three and a half miles " long, and takes in the hills of Carn Brea, Carn Tregajorran, Carn Arthen, " Carn Entral, and Camborne Beacon, and is divided from the main formation " by a breadth of slate (principally micaceous) from a quarter to a half a mile " wide. The Carn Marth range takes in the hill of that name and Trefula " Beacon, and is divided from the main granite by slate at Wheal Beauchamp." MR. THOMAS, *Mining Review*, No. VIII. p. 265, and "*Maps of the Carn Menelis* " *district*," in the Museum of the Royal Institution of Cornwall, at Truro.

‡ " The mines of Dolcoath, Cook's-Kitchen, Tincroft, Wheal Fanny, Trega- " jorran, and Wheal Druid, are near the division between the granite and killas; " but are within the killas ground at the surface. In these mines it is observed, " that strata of granite and killas appear alternately overlaying each other, the " divisions between them being at various inclinations." MR. THOMAS, " *Report*," p. 10. See also Mr. Carne, Cornwall Geo. Trans. II. p. 75, and Mr. Hawkins, Ibid. p. 378.

Tincroft,* and to a trifling extent in *Dolcoath*† and in the *Cairn Brea Mines*, are, perhaps, the most remarkable peculiarities of the district.

In the southern part of *Cook's Kitchen* a decomposing coarse grained granite appears at the surface and continues downward for about 13 fathoms; it is then succeeded by a bed of slate which reaches to a depth of 39 fathoms. This slate in its upper part is deep blue and crystalline, and has but imperfect traces of a schistose structure; but lower down it becomes by degrees more micaceous, with a more decided cleavage. Veins of granite penetrate the slate both at its upper and lower surfaces.

From 39 to 49 fathoms deep, there is a bed of granite which is much finer grained than that at the surface, and it abounds in schorl. Below this for a great many fathoms, beds and masses of granite and slate alternate and mix in a very irregular manner. Sometimes the transitions are very gradual, at others abrupt; and in most, if not in all, cases, there are

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* "Some remarkable alternations of schist and granite were discovered while "working the two veins on the south, * * * in some parts of Dunkin's vein, "granite was found on one side of it and schist on the other, and detached "masses of each substance were found both in it and in the south vein; and "frequently where granite formed the country on each side of the vein, the "masses were of schist, and vice versâ.

MR. WM. PHILLIPS, *Geo. Trans.* II. p.p. 152-155.

† "We had positive proof, that what had, in Dolcoath mine, been considered "as a bed of granite alternating with the killas, was in reality a lancet-shaped "mass, proceeding directly from the fundamental rock, and wedging out in the "killas." PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p. 122.

I confess, that whether these be considered alternating beds, or mere projections from the main body, appears to me of no consequence either in descriptive or theoretical geology. Whatever they may be, their mode of aggregation, and their mineral composition are not always the same, in *Cook's Kitchen*, at least.

veins of granite traversing the slates. These irregularities seem, however, to be confined to the southern part of the mines, and although patches and lumps of granite appear in several places far from the main body, and from any of the great beds of that rock, none of them occur north of the Hardshaft lode. At 73 fathoms deep, the granitic bed extends northward, to within a short distance of that vein.

In *Tincroft* mine, granite descends from the surface to 26 fathoms deep, at *Dunkin's lode*; but although it accompanies that vein for a few fathoms and forms both its *walls*, yet at that depth, both on the north and south, the slate soon appears: below 26 fathoms *Dunkin's lode* is in slate. Here also, the slate, wherever it is in contact with granite, is traversed by small veins and strings of that rock. At 84 fathoms deep, the main body of the granite appears.

Near *Martin's lode*, in the same mine, there are several irregular patches of granite. Two of these include a small mass of slate, in appearance like a vein,* between them; and all are *heaved* by the eastern *cross-course*. A third mass rises to within 25 fathoms of the surface, and is intersected by the same *cross-course*, but it is not *heaved*.

It is not known whether all these interlying masses of granite are connected with the main body

* "We have looked again and again, and cannot perceive that nature has "made any distinction between granite veins and slate veins; we can only see "in this peculiar form of matter, elongated portions of the respective rocks,— "which may be either connected therewith, or entirely insulated in the tra- "versed mass." DR. BOASE, *Primary Geology*, p. 352.

of that rock. That some of them, however, are so in *Cook's Kitchen* is evident, as a *cross-cut* is carried many (about 80) fathoms south through one of them, at a depth of 68 fathoms, and the whole rock is found to be granite.* It has not been ascertained how far northward the beds which appear at the surface in *Cook's Kitchen* and *Tincroft* may extend; they probably do not reach many fathoms beyond the places of examination already noticed, as other shafts have been sunk, in which they have not been discovered.

The contact of the great granitic mass with the slate is very frequently distinct, though sometimes the transition from one to the other is gradual; but in almost every case there are numerous veins and beds of granite in the slate.

The slate which joins the granite is often a deep blue and crystalline rock, chiefly composed of compact felspar and hornblende, which in many of its beds affords actynolite, axinite, &c.; as, for example, at *North Roskear, East Wheal Crofty,* and *Wheal Wellington:* but this is frequently in very irregular patches;†

* An *elvan-course* occurs in the granite, in the southern part of *Cook's Kitchen*.

† "The Ire-stone, or Iron-stone is by much the hardest of all strata, and "borrows this name from its extreme hardness, and not because it contains "iron. It is of a dark bluish colour, like lead that has been long exposed to "the weather; and usually so hard, that it must be wrought with steel borers, "and then blown by gunpowder. It often keeps a course east and west like a "lode, but is commonly very wide; and therefore it is very tedious and change-"able, where an adit must be driven across it. It is this stratum that is "uppermost through great part of the middle of Camborn and Illugan parishes, "where many principal Copper Mines are enclosed in it. Tin lodes are very "seldom found in Ire-stone." Mr. Pryce, *Mineral. Cornubi.* p. 75, (1778).

"A large course of iron-stone (of extremely minute granular hornblende, "in which are visible very small portions of compact felspar and quartz)

and the rock in contact with the granite is sometimes variegated red and white, schistose, and it is then probably composed, for the most part, of felspar and mica.

The more common slate rock is, however, thick lamellar, and of a deep blue, having some shades of purple, and occasionally alternating with thin greyish bands; it often contains mica in the planes of its imperfectly slaty cleavage.*

This district affords many excellent examples of *elvan-courses*. The most northerly one with which I am acquainted, occurs between the E. and W. *lodes* in *East Wheal Crofty*, and is quarried from the eastern side of Tucking Mill through Roskear as far as Camborne.† In *East Wheal Crofty* it is 6 fathoms wide and dips N. 60–70°.

" appears to extend from Camborne through Tucking-mill, to Treleigh (north of " Redruth), at which places, large blocks of the stone are lying on the surface, " and may be seen in great quantities in the large open pits at South Roskere " Mine. The line of its direction may be traced in the roads at Pool, Highway, " and Tolgus. This course appears to hold a regular direction, as shown in the " Map, nearly the same as the lodes; but, nevertheless, seems for the chief part " to be composed of irregular detached masses." Mr. Thomas, "*Report*," p. 18.

" Veins of Iron-stone or Ire-stone * * are generally very large and run " nearly east and west. The principal of those veins is about 20 fathoms wide, " and is supposed to extend several miles in length, eastward from Roskeere " in Camborne. Another vein of it has been found in Tincroft mine, about the " same width." Mr. Carne, *Cornwall Geo. Trans.* II. p. 61.

* " At Dolcoath the *killas* is a hard purple coloured rock, which breaks into " thick laminæ; in consequence of the minute scales of mica which enter " largely into its composition, sometimes the mica is almost entirely wanting, " the rock is then a kind of compact felspar; and is occasionally much inter- " mixed with quartz." Dr. Boase, *Cornwall Geo. Trans.* II. p. 312.

† " An Elvan about 40 feet wide, between Camborne and Dolcoath mine, " ranges nearly east and west, and underlies south."

Professor Sedgwick, *Cambridge Phil. Trans.* I. p. 129.

" Between Camborne and Tuckingmill, a large *elvan-course* is quarried; it " is a felspar porphyry, and runs nearly E. and W., *underlying* to the N., " according to the quarrymen." Dr. Boase, *Cornwall Geo. Trans.* IV. p. 311.

The second *elvan* appears in *East Pool*, and is quarried in two places N. of *Tincroft* and *Cook's Kitchen*, again a few fathoms N. E. of the counting-house at *Dolcoath*;* and it is seen at 70 fathoms deep in the western part of that mine (*Pl. VI. Fig.* 2.) and also in *Stray-park*. This is most probably the same *elvan* which is quarried near the Work-house on the northern slope of Camborne Beacon Hill. In *Dolcoath* it dips N. 50–60°, and is 12 fathoms wide.

A third *elvan-course* appears in the adit of *Tincroft*, and at the surface near the counting-house of the same mine; again at 73 fathoms deep in *Cook's Kitchen*, and near the *caunter-lode* in *Dolcoath* at a depth of 96 fathoms. In the first of these localities it is 6 fathoms wide, and dips N. 60–70°. With its further course westward I am unacquainted.

Another *elvan* is seen at 68 fathoms deep in *Cook's Kitchen*; it is 17 fathoms wide, and dips N. 70–80°.

There are two *elvan-courses* in the *Cairn Brea Mines*, both of them dip N. 50–70°, and are seen in both granite and slate; the southern one is 7 fathoms wide, the other is narrower. In the Hayle railway-cutting, N.E. of the *Cairn Brea* mines, there are two or three courses or beds of a coarse grained decomposing rock, consisting of felspar and quartz, with

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* "The *elvans*, or granitical rocks, are quartzose: (some of them are) fine "grained, affording an easy passage into the * * compact felspars; (others "are) large grained, contain flesh-coloured crystals of felspar, and approach "nearer to granite." Dr. Boase, *Cornwall Geo. Trans.* I. p. 312.

mica and schorl occasionally interspersed. These beds apparently alternate with others of a decomposed reddish-brown slate, which in two or three places is traversed by small veins of the felspar rock. The joints traverse both rocks and bear about N. W. The whole is, however, so covered and concealed by rubbish that it is not easy to discover its real nature.

The same remark equally applies to a bed of granite (throwing off veins into the slate) which occurs in another cutting for the same railway, near *Cook's Kitchen*, and seems to be composed of felspar, quartz, and mica, and to dip towards the N. W.*

There are traces of *elvan* N. of *North Roskear*, but I have not seen a regular *course* of it there. An *elvan-course* appears on the road immediately N. of Cairn Brea Castle; and another in the Blowing-house hill; but I am unable to determine whether either of these has any relation to those in the *Cairn Brea Mines*.

All these *elvans* consist of a basis of confusedly crystalline felspar and quartz; they usually contain porphyritic crystals of felspar, and often some schorl.

When in the granite they are frequently more quartzose than they are in the slate.

They furnish, almost exclusively, the building stone for the whole of the neighbourhood.

The principal *lodes* of the district have a bearing which varies from 20° to 40° S. of W.; but some

* Perhaps this is the outcrop of the superficial granite at *Cook's Kitchen*; but if it be so, it cannot be connected with that near *Dunkin's lode* in *Tincroft*, as a mass of slate intervenes.

of them dip north and others south. The *Main-lode* and *Harriette's lode* in *Dolcoath*, the principal *lode* in *North Roskear*, two of the chief *lodes* in *Cook's Kitchen*, and the most considerable *lodes* of *Tincroft*, dip towards the south; but in the same mines, and in *East Wheal Crofty*, there are other *lodes* inclining to the north, which have also been very productive.

There are several *caunter-lodes*, (or veins bearing from 10° to 30° N. of W.) in this district; and the greatest produce of *Dolcoath*, of *Wheal Crofty*, and of *East Wheal Crofty* have, during the recent workings, been derived from them; but they have, almost exclusively, yielded copper ore.

Copper pyrites is by far the largest product of this neighbourhood; but several mines have also afforded abundance of native copper,* and of vitreous and black copper ore: as, for example, *Dolcoath*, *Cook's Kitchen*, *Tincroft*, the *Cairn Brea Mines*, &c., and the same mines have also yielded many of the rarer and more splendid compounds of that metal.

Very large quantities of tin ore have been, and still continue to be, raised in *Tincroft*, the *Cairn Brea Mines*, *Cook's Kitchen*, and *Dolcoath*.

In one of the *lodes* at *Dolcoath* much native silver, as well as vitreous and red silver ore, were

* At *Condorrow* some very large masses of native copper were found; one of them, weighing 122 lbs., was presented to the Museum: the mode of its occurrence described by E. W. W. Pendarves, Esq., M.P., F.R.S., Cornwall Geo. Trans. III. p. 333.

found;* and in the same mine some of the ores of cobalt and bismuth have also occurred.

This district contains several *cross-courses*, which bear between N. and N.W.; in general they have much less inclination (from the perpendicular) than the *lodes*; and their contents are chiefly quartz and clay. But they, as well as the *lodes*, as soon as they pass from one kind of rock to another, alter in their mineral character, and assume a sort of resemblance to that which they traverse. Several of them appear at some depth, but are not visible near the surface.†

In the western part of the district, especially, the *heaves* are trifling, and they are no where considerable, except that occasioned by the *great cross-course*, which runs a little W. of N., nearly parallel to the valley separating *Dolcoath* from *Cook's Kitchen*, and *Wheal Crofty* from *East Wheal Crofty*. The extent of the *heave*, by this *cross-course*, has never been exactly ascertained, but it has been supposed to be from 50 to 70 fathoms to the right.‡

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* The noble family of Basset, the proprietors of the land, preserve as an heir-loom a splendid piece of plate, which was manufactured out of the silver raised from *Dolcoath*, and presented to the late Lord de Dunstanville by the adventurers in that mine, as a testimony of their gratitude for his kind and liberal relinquishment of the Lord's *dues*, whenever the poverty of the concern rendered an increased outlay necessary.

† "This (cross-course) does not appear to come up to the surface, being found "only at a great depth," &c. MR. THOMAS, "*Report*," p.p. 35-6.

See also *Dolcoath*, Table L.

‡ "At the *Cook's Kitchen great cross-course* there appears to be a *heave* to "the right about seventy fathoms." MR. THOMAS, "*Report*," p. 23.

"The mines of Dolcoath and Cook's Kitchen are divided by a cross course, "and the lodes are heaved to the right 50 fathoms."

MR. CARNE, *Cornwall Geo. Trans.* II. p. 99.

It is universally the case, that whatever may be the dip of the *lodes*, the same *cross-course heaves* all of them towards the same hand.

The *cross-courses* traverse all the *elvan-courses*, but *heave* none of them.

The joints, as far as I have observed, traverse all the rocks and veins without interruption; and, in general, the principal ones have a sort of coincidence with the direction of that system of veins which is in their immediate vicinity.*

The principal mining operations are on two series of parallel *lodes;* one, passing through *Stray Park, Dolcoath, Cook's Kitchen, Tincroft,* and the *Cairn Brea Mines;* and the other, through *North* and *South Roskear, Wheal Crofty, East Wheal Crofty,* &c.

Cairn Brea is the highest land in the district,† and near its summit there is a copious spring of excellent water. The magnificent rocks of this celebrated spot are "too well known to need description;"‡ the other hills are equally barren, but do not possess the same interest, either for the lover of scenery or the antiquarian.

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* As the veins are the chief subterranean aqueducts, the joints near them may possibly be better developed by the decomposing action of the water flowing through them.

† Mr. Thomas states the elevation of the top of the Castle, above high-water mark, to be 710 feet, and of the highest rocks, 740 feet.

‡ I am indebted to the kindness of Mr. Thomas for referring me to an instructive instance of granite veins traversing the slate of this district, which has recently been discovered, in a quarry on the western side of the valley which divides Illogan from Redruth.

The slate is an irregularly laminated felspar rock, of a deep brown colour; dipping N. 20–30°, the joints bearing E. and W. One of the granite veins is about a foot wide, and the other two or three inches; both dip southward, and bear about S.E. and N.W. They are rather fine grained, and consist of felspar, (much decomposed) with a little quartz and mica.

In the southern part of the district a little *str tin* has been found.

The lower grounds near the mines are, of co usually covered with rubbish; when this is no case, there are many fertile meadows.*

* "In many places in the valleys, spots have been enclosed whic "formerly turned over by the streamers in search of tin, where nothing ap "to remain but heaps of stones. These have been levelled, and the littl "contained in them carefully preserved and put on the surface, and no "good meadows." MR. THOMAS, "*Report*," p. 15.

	162.	E.68-80°	10 in. to 3 ft.	Compact greenstone, quartz, and earthy brown iron ore.	Greenstone, fine grained, and crystalline.	5 feet —	*Lode heaved*, 3 feet L.G.A.
	178.	E.52-60°	6 to 8 inches.	Decomposed slate, and numerous small veins of quartz.	Between the two *cross-courses* and the *lodes*, there is a mass of fine grained schorlaceous granite, which gradually passes into the contiguous greenstone.	*Lode* divided, but not *heaved*.	*Lode* divided, but not *heaved*.
	188.	W64-70°	2 to 3ft.	Soft white slate, slaty clay, and quartz	.....	Idem.	Idem.
Boundary Cross-course 40° N. of W.	146.	N.E. 66–88°	0.8 to 1.5 ft.	Slaty clay, earthy brown iron ore, and quartz.	.....	The intersection is confused.	*Lode* divided, but not *heaved*, but the N. *wall* appears so to be, from the *lode* varying in breadth on opposite sides. See above (*a*).
	162.	S.W. 76–80°	2 in.	Felspar clay, and quartz.....	.....	*Lode heaved*, 3 feet R.G.A.	*Lode heaved*, 2 feet R.G.A.
	178.	N.E. 74–86°	4 to 6 inches.	Soft slate, and veins of quartz.....	.....	*Lode* divided, but not *heaved*.	*Lode* divided, but not *heaved*.
	188.	S.W. 60–70°	—	In three *branches*; quartz, and earthy red iron ore.	.....	Idem.	Idem.
	198.	S.W.64°	10to14 inches.	Irregularly shaped masses of quartz, and blue slate of a silky lustre.—many of them are round; there are many small cavities (*vughs*) lined with crystals of quartz.	.....	Idem.	Idem.

RNE. (*Pl. VI. Fig. 1–2–3.*)

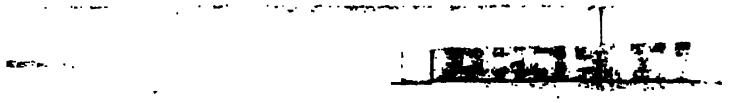
Rock.	Entral North Lode.	Main Lode.	Caunter Lode.	Harriette's Lode.
e, schistose struc- 25°.				
pping N. 50–60°, d schorl, enclosing enes between the *Lodes;* it is inter- by *Wheal Bryant*				
avage N. 16° ; E. t, and it becomes laceous.	.....	.....	Contact distinct. (*a*)*	
luish hornblende, s very quartzose.	.....	.....	The *Caunter lode* is split into strings at the junction. (*b*)	
cleavage planes,				
ite and slate which adual shades ; the s very felspathic, also quartz, and				
par, quartz, and stals of white and				

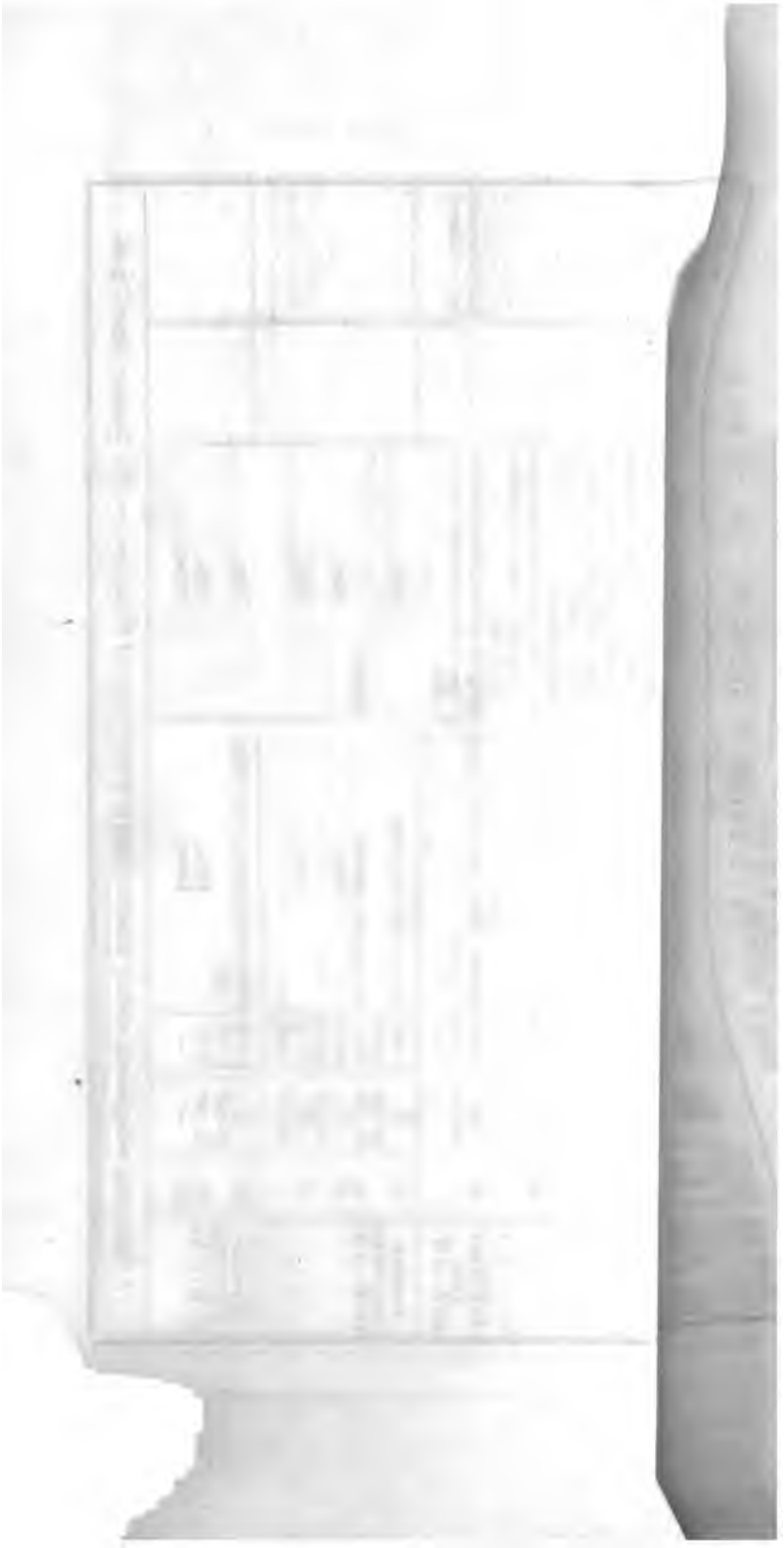
N.* *(Pl. VI. Fig. 4–5.)*

	South Lode.	Great or Dunkin's Lode.	Middle Engine Lode.
pathic, and dipping S.			
blue, with with traces wards it be- ntains much eavage dips veins of gra- upper and			
schorlaceous, g off into a uch schist.			
p N.W. 34°. veen the slate mixture of			
minute veins			

. FIG. 6–7.)

	Martin's Lode.	Western Cross-course.	Eastern Cross-course.
ip of	.....	.....	*Cross-course* traversed, but not *heaved*.
-16°;	.....	*Lode heaved*, 2 fms. R.G.A.	
rallel	Westward from 84 to 116 fms. deep, *Martin's* and *Highburrow lodes* unite, and form a mass of from 8 to 10 fms. wide, which has been all removed for the oxide of tin it contained.	.....	*Lode heaved*, 1 foot R.G.A.
with f the y red es of			
, and of W. mica,	.....	*Lode* intersected but not *heaved*.	
	.....	*Lode heaved*, 2 feet R.G.A.	
avage	.....	*Lode* confused, but still apparently *heaved* R.	
.....	*Martin's* and *Highburrow lodes* here fall in contact, and continne together on the dip and bearing of the latter.		





Dir. of vein.	fms.	Dip.	Size.	[illegible]	
Lode, 32° S. of W.	107.	S. 56–76°	0.6 to 2 feet.	Decomposed greenstone, disintegrated iron pyrites, and quartz.	*Greenstone*, compact felspar, with traces of a greenish colouring mineral,(?) hornblende, or actynolite.
	117.	N. 62–68°	4 to 10 inches.	E. Slaty clay, having appearances of a jointed structure.	
	—	N. 68–76°	1.5 to 2 feet.	W. Quartz, quartzose slate, copper and iron pyrites.	Deep greyish green, crystalline, and massive; there are numerous alternating beds of dark brown felspar, and of hornblende.
	129.	N. 65–74°	10 in. to 2 ft.	Quartz, quartzose slate, copper pyrites, and blende.	Idem. E. The same rock, with confused appearances of cleavage planes.
	139.	N. 76–85°	1.5 to 2 feet.	Quartz, and quartzose slate, with a few spots of copper pyrites.	Idem; dip of cleavage N.W. 32°.

OF CAMBORNE. (*Pl. V. Fig. 2-3-4-5-6.*)

of Rock.	N. Roskear Lode.	Wheal Crofty Caunter Lode.	Engine Lode.	South Lode.
passing into brown, bear S.E. & N.W. re traces of cleav- le grained.				
hard.				
talline, and hard, s irregular joints.				
n.				
th numerous joints.				
m.				
m. m.				
m.				
m. rained, and crystal-				

						Caunter Lode.	
Longclose Main Lode, 15° S. of W.	30.	N. 80-85°	1 to 1.5 foot.	Quartz, quartzose slate, and copper pyrites.	*Greenstone*, massive, hornblende, and felspar, with beds of compact felspar, and traces of axinite.	*Caunter-lode* intersected, but not *heaved*.	
	46.	P. S. 80°	1.5 to 2 feet.	Idem	Idem	Idem.	
	54.	N. 80° P.	1 to 2.5 feet.	Idem	Idem, the joints are numerous, and bear S.E. and N.W.	*Caunter lode heaved* 3.5 fms. R.S.A.	
	65.	N. 78° S. 82°	1 to 4 feet.	Idem, with fluor and blende between the points of contact with the *Caunter lode*.	Idem	5.5 fms. R.S.A.	
	75.	N. 70-82°	3 to 4 feet.	Quartzose slate, quartz, and spots of iron and copper pyrites. Two veins in some places.	Deep green; joints N. and S.		
	85.	N. 48-60°	1.5 to 2 feet.	A vein of slaty clay N. *wall*, quartz S.	Slate, decomposing, greenish grey; dip N. 18°: joints N. and S.		
Longclose Caunter Lode, 30° W. of N.	30.	N.E. 85-82°	1 to 2 feet.	Quartz, fluor, copper and iron pyrites.	Crystalline hornblende slate; dip N. 70°: joints very numerous and irregular, but chiefly N. and S., and S.E. and N.W.		
	46.	N.E. 80° P.	1.2 to 1.5 ft.	Quartz, quartzose slate, iron and copper pyrites, and fluor.	Compact, brownish blue, with irregular strings of axinite, and actynolite.		
					and compact felspar.		

Dtn. of vein.	fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Longclose Caunter Lode.	Reeve's Lode.
LONGCLOSE MAIN LODE, 15° S. of W.	30.	N. 80-85°	1 to 1.5 foot.	Quartz, quartzose slate, and copper pyrites.	*Greenstone*, massive, hornblende, and felspar, with beds of compact felspar, and traces of axinite.	*Caunter-lode* intersected, but not *heaved*.	
	46.	P. S. 80°	1.5 to 2 feet.	Idem.....	Idem.....	Idem.	
	54.	N. 80° P.	1 to 2.5 feet.	Idem.....	Idem, the joints are numerous, and bear S.E. and N.W.	*Caunter lode heaved* 3.5fms. R.S.A.	
	65.	N. 78° S. 82°	1 to 4 feet.	Idem, with fluor and blende between the points of contact with the *Caunter lode*.	Idem.....	5.5 fms. R.S.A	
	75.	N. 70-82°	3 to 4 feet.	Quartzose slate, quartz, and spots of iron and copper pyrites. Two veins in some places.	Deep green; joints N. and S.		
	85.	N. 48-60°	1.5 to 2 feet.	A vein of slaty clay N. *wall*, quartz S.	Slate, decomposing, greenish grey; dip N. 18°: joints N. and S.		
LONGCLOSE CAUNTER LODE, 30° W. of N.	30.	N.E. 85-82°	1 to 2 feet.	Quartz, fluor, copper and iron pyrites.	Crystalline hornblende slate; dip N. 70°: joints very numerous and irregular, but chiefly N. and S., and S.E. and N.W.		
	46.	N.E. 80° P.	1.2 to 1.5 ft.	Quartz, quartzose slate, iron and copper pyrites, and fluor.	Compact, brownish blue, with irregular strings of axinite, and actynolite.		
					and compact felspar.		

	54.	N.E. 70° P.	0.5 to 2 feet.	Quartz, containing numerous *vughs* lined with crystals of quartz, fluor, and copper pyrites.	Idem, often inclining to green.		
	65.	N.E. 80° P.	1 to 3 feet.	Quartz, fluor, blende, and copper pyrites.	Crystalline, fine grained; joints bearing N.W.—numerous.		
	—	N.E. 60–70°	1 foot.	N.W. Quartz, slate, and blende.	Idem, obscure traces of slaty cleavage.		
	75.	N.E. 70–80°	1,5 ft.	Blende, quartzose slate, and spots of copper pyrites.	Idem.		
	—	—	—	In several veins, mere lines.....	Idem, decomposing.		
	85.	N.E. 65–72°	1 to 1.5 foot.	Crystalline quartz, and slaty matter.			
CHERRY GARDEN LODE, 15° S. of W.	71.	N. 70–80°	1 to 2 feet.	Crystallized quartz, slate, blende, iron and copper pyrites.	Crystalline, fine grained, greenish brown, with irregular strings of axinite, and actynolite.		
	88.	N. 56–70°	—	Quartz, slate, and spots of copper pyrites.	Idem; numerous joints bearing N.W.		
TREVENSON LODE, 2° N. of W.					An *elvan course* of 6 fms. wide occurs between *Cherry Garden* and *Trevenson lodes*. It bears S.W. and dips N.W., and is composed of felspar, & quartz, with a little schorl.		
	55.	N. 70–76°	2 to 4 feet.	Quartz, greenstone, copper and iron pyrites.	Greenstone, fine grained, and crystalline.		
	65.	N. 68–76°	3 to 5 feet.	Idem.	Idem.		
	73.	N. 60–66°	4 to 5 feet.	Quartz, and greenstone, with spots of copper pyrites.	Idem.....	.....	Near the junction both *lodes* divide into strings.
	90.	N. 55–64°	6 to 8 feet	Crystalline quartz, slate, and traces of copper pyrites.	Idem.....	.....	Idem.

Table LVI.

		50–60°		with greenstone between them.	.....	.....	
	110.	—	7 to 10 feet.	Idem.....	Idem	.....	Idem.
	120.	—	?	Greenstone, with a little quartz....	Idem.		
Reeve's Lode, 30° W. of N.	55.	N.E. 70-80°	1.5 to 3 feet.	Quartz, chlorite, iron and copper pyrites, with vitreous copper ore, and earthy brown iron ore.	Greenstone, near the *lode* often decomposed.		
	65.	N.E. 68–76°	2 to 4 feet.	Idem.	Idem.		
	71.	N.E. 72–84°	—	Idem.	Idem.		
	90.	N.E. 76–85°	1.5 to 5 feet.	Iron & copper pyrites, quartz, fluor, and chlorite.	Crystalline, and abounding in strings of chlorite, axinite, and actynolite.		
	100.	N.E. 85° P.	6 to 8 feet.	Granular quartz, slaty clay, iron and copper pyrites, blende, and fluor. The copper pyrites next the N. *wall*.	Pale greenish white felspar, with spots of chlorite, decomposed.		
	110.	N.E. 80–85°	—	Idem. The copper pyrites is generally in small veins traversing the other substances.	Idem.		
	—	N.E. 70–74°	3 to 4 feet.	W. Quartz, greenstone, and spots of copper pyrites.	Crystalline, fine grained, and very hard.		
	120.	N.E. 70–80°	2 to 3 feet.	W. Idem.....	Idem.		
	—	N.E. 78–85°	3 to 4 feet.	E. Quartz, clay, iron and copper pyrites, with fluor, and blende; a little mineral pitch.	Greenish grey, much decomposed, with many short unctuous joints.		
	125.	N.E. 80–84°	4 to 6 feet.	Clay, chlorite, fluor, iron and copper pyrites; with spots of mineral pitch.	Idem.		
Fane's Lode, 8° S. of W.	71.	N. 70–76°	2 to 3 feet.	Quartz, greenstone, and a few spots of iron and copper pyrites.	Crystalline, fine grained, brownish blue, with veins of axinite, and compact felspar.		

Fig. 2.

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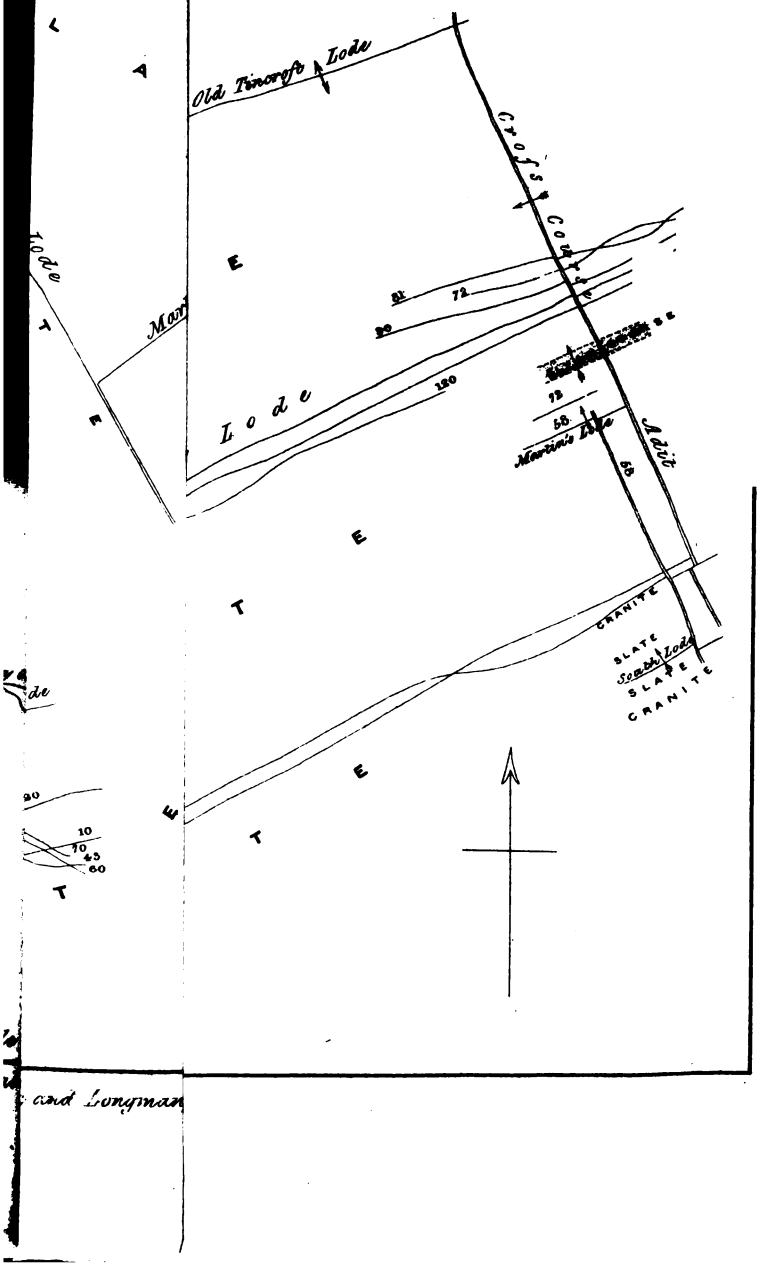

and Longman

THE REDRUTH AND GWENNAP DISTRICT,

Touches the Camborne and Illogan district on the north-west. It is bounded on the west by a line drawn from Blowing-house-bridge to the *Elvans* mine; on the south, by another line extending from the *Elvans* to Comfort, and, by the valley, from thence to Bissoe-bridge; on the east, by a third imaginary line from Bissoe-bridge to Seveock-water; and on the north, by the Redruth and Truro turnpike-road, from Seveock-water as far as White Hall, and thence by an irregular line to *North Downs*, and continued through Treleigh to Blowing-house-bridge.

It includes portions of the parishes of Redruth, Gwennap, Perran-ar-worthal, Kea, and Kenwyn.

Its rocks are the north-eastern skirt of the great granitic range of Stythians, Wendron, &c., and the isolated mass of granite forming Cairn Marth and Trefula-beacon,* and the slate-rocks in contact with them. The whole is traversed by numerous *elvans*, *lodes*, *cross-courses*, and *flucans*, and is by far the most extensive as well as the most productive mining district, particularly in copper ores, in Cornwall.† It has been ably and accurately illustrated by my friend Mr. Thomas,‡ and I have but little to add to his description.

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* "The Carn Marth range takes in the hill of that name and Trefula Beacon, "and is divided from the main granite by slate at Wheal Beauchamp."
MR. THOMAS, *Mining Review*, No. VIII. (June, 1836), p. 265.

† M. Hèron de Villefosse, De la Richesse Minéral, I. p. 292.

‡ "Report on a Survey of the Mining District of Cornwall, from Chasewater

The granite of the larger mass joins the slate at *Wheal Buller*,* *Penstruthal*, and *Tresavean*,† whence it rapidly trends towards the south-east. That of Cairn Marth extends westward as far as *Wheal Beauchamp*,* and thence northward to *Pedn-an-drea*, on the east of Redruth; it then stretches north-eastward and crosses the turnpike-road, but nowhere runs far north of it. The line of junction again crosses the road at Shallow-adit, and appears on the south of *Treskerby;* thence, continually bending towards the south, it passes through *Wheal Pink* moor, *Wheal Gorland*, the western parts of *Wheal Unity*, *Poldice*, *Wheal Jewel*,‡ *East Wheal Damsel*,§ Carharrack, *Ting Tang*,‖ and westward on the south side of Cairn Marth,¶ back again to *Wheal Beauchamp*.*

The actual contact of the granite and slate is nowhere visible at the surface, as it is concealed by the soil, but its position can generally be discovered within very narrow limits; underground, however, it may be seen in *Wheal Buller* and *Wheal Beauchamp*,* *Wheal Gorland*,** *Wheal Unity*, *Poldice*,†† *Wheal Jewel*,‡‡ *East Wheal Damsel*,§ and *Tresavean*,†

" to Camborne," with a Geological Map and Sections, (London, 1819): Geological Survey of the Carn Menelis District, Mining Review, No VIII. (June, 1836), p. 263: and Maps of the same tract, in the Museum of the Royal Institution of Cornwall, at Truro.

* Table LVIII. † Table LIX. ‡ Table LXV. § Table LXIV. ‖ Table LX.

¶ " The grauwacke covers the lower part of Carn Marth, and rises exactly " to the height of five hundred and forty-three feet, which is about two-thirds " of that of the mountain." DR. BERGER, *Geo. Trans.* O.S. I. p. 155.

** Ibid, p. 146.

†† Mr. R. W. Fox, Phil. Trans. (1830), pp. 410–413, fig. 5-19*.

‡‡ Ibid, p. 409, fig. 2, and Table LXV.

and in the now abandoned mines of *Pedn-an-drea, Treskerby,* Ting Tang,*† and *Penstruthal.*

The granite both of the greater range and of the smaller patch underlies the slate, and at *Tresavean*‡ the line of junction dips N.E. 40°: at *Wheal Buller,*§ which also adjoins the great southern mass, the dip is N.E. 60°. At *Wheal Beauchamp*§ the granite of Cairn Marth dips S.W. 40–50°; at *Ting Tang,*† on the east of the same hill, it dips S.E. 40–45°; and at *East Wheal Damsel*‖ it inclines E. 14–16°; or in 276 fathoms in length it dips 70 fathoms.

At *Wheal Beauchamp*§ a bed of granite, 20 or 30 fathoms thick, extends from the Cairn Marth range and overlies the slate for several fathoms; and the granite of Lanner-beacon, which belongs to the Stythians and Wendron tract, at the *North lode* in *Wheal Buller,*§ in the south *wall,* which is nearest to the main mass, is 10 fathoms further east than it is in the opposite one: at *Tresavean,*‡ on the contrary, the granite extends 5 or 6 fathoms further east on that side of the *lode* which is most distant from the central body; in the first instance the *lode* dips northward, in the second it is, on the whole, nearly perpendicular.

Granite veins traverse the slate at *Wheal Buller* and *Wheal Beauchamp,*§ *Wheal Gorland,*¶ *Poldice* and *Tresavean;*‡ and the *elvan* at *Ting Tang*† is similarly penetrated. At *Pedn-an-drea,* and thence

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* Mr. Thomas, Sections 2 and 8.

† Table LX. ‡ Table LIX. § Table LVIII. ‖ Table LXIV.

¶ Dr. Berger, Geo. Trans. o.s. I. p. 146.

a furlong or two southward, at Healed-shop, and at *East Wheal Sparnon*,* two masses of granite extend some distance into the slate. In these the granite is generally much decomposed, and the fine quarry of slate at High-burrow is worked between them; the slate also on the western slope of Cairn Marth is, for some distance, covered with large granite boulders.†

At *Wheal Buller*‡ several unconnected masses of granite are enveloped in the slate at 49 fathoms deep.

The mineral composition of the granite is much the same as in the other districts; viz., a basis of felspar, quartz, and mica, enclosing crystals of felspar, and, occasionally, of quartz. In many places schorl abounds; and at *Wheal Buller*‡ chlorite replaces the mica, and here and there the rock is merely felspar and chlorite.

At *East Wheal Damsel*,§ and at *East Wheal Sparnon*, fluor is dispersed through the granite: in the former instance it is often purple, but in the latter it always has a greenish hue.

At *Wheal Vyvyan*, in Constantine, near the southern boundary of the great granitic range of Stythians, Wendron, &c., there is a very remarkable metalliferous formation. It has the character of an enormous

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* Mr. Thomas, "Report," p. 37.

† "The upper part of Carn Marth (about one-third) is granite; large blocks "are strewed over this part of the mountain, and they appear to have been "rolled from the summit." DR. BERGER, *Geo. Trans.* o.s. I. p. 154.

‡ "These rocks and stones have probably rolled down from the summit or "from the sides of the hill * * *. The same has been observed on the sides "of Carn Marth. MR. THOMAS, "*Report*," p. 11

§ Table LXIV.

granitic *lode*, bearing 20–30° S. of W., and dipping 35–50° N., is from 5 to 10 fathoms wide, and in some places even more. Its composition differs little from the *country* near it, except that perhaps it contains a rather smaller proportion of mica: they have both a porphyritic structure, with buff and flesh-coloured crystals of felspar. The whole substance of the *lode* is thinly interspersed with tin ore, copper pyrites, and also with spots of iron pyrites, and here and there a little vitreous copper ore. These metalliferous minerals are, however, chiefly disposed in small veins and strings, which most commonly have the direction of the *lode*, and generally a northern inclination: the joints in the rock seem to coincide with the veins both in bearing and dip, and where there are crevices in them their faces are commonly coated with fine crystals of tin ore.

There are also veins of granite in the *lode* which dip S., and sometimes cut off the small strings of tin and copper ores and *throw* them upwards *(Pl. VIII. Fig. 6.)*; some *cross-courses* also displace the *lode*.*

The whole of this remarkable deposit resembles those of *Balleswidden*,† *Cligger*,‡ *Carclaze*,§ and the *Bunny*,‖ in granite; and of *Wheal Music*,¶ and *Polberrow*,** in slate; except that in neither of the others do the ores of tin and copper occur together.

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* By one of the *cross-courses* the *lode* is *heaved* to the right.

† *Ante*, p. 15. ‡ See p. 94. § Ibid, p. 120. ‖ Ibid, p. 121.
¶ Ibid, p. 98, *note*. ** Ibid, p. 101.

Here, as at *Carclaze*, the *Bunny*, and *Wheal Music*, nothing but the extent of the metalliferous tract, and the opportune concurrence of abundant streams of water which furnish a cheap moving-power for the machinery, could make a profit to the adventurers from so slight a sprinkling of ore.

The whole of the granite in this district is much finer grained than it is in the western tracts.

At *Tresavean** a massive schorl-rock, which is principally schorl with a trifling proportion of quartz and felspar, intervenes between the granite and the ordinary slate of the district. In some parts of *Wheal Beauchamp*† a somewhat similar rock prevails; whilst at *Wheal Buller*† the chloritic rock, already mentioned, is interposed between the granite and the chlorite slate which occurs there.

A coarse-grained arenaceous slate of a reddish colour with a great deal of mica arranged between its laminæ, and its cleavage dipping N.E., occurs at *Wheal Sparnon;* and several laminated varieties of schorl-rock, often disposed in parallel black and white layers, and these, too, frequently much curved and contorted, are interposed between the granite of *Pedn-an-drea* and the massive schorl-rock of *Wheal Beauchamp.*†

Between the granite and *Cardrew Downs* mine the rock is a very thick-bedded blue slate, in some places

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* Table LIX. † Table LVIII.

‡ "Proceeding northward, an extensive barren down succeeds; and the "rock immediately under it consists of a red disintegrated slate, traversed by "numerous quartz-veins, next which the rock is of a bright brick-red and "friable." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 292.

it becomes red‡ with rather an irregular cleavage; and towards *Treskerby* it changes to a bluish-white slate which decomposes very rapidly on exposure.

Near Tregullow there is a decomposing coarse-grained micaceous slate, and at the western part of *Poldice** a thick-bedded brick-red mica slate, which is probably the same rock in a perfect state.† A variegated greenish or greyish-white slate, rather soft and disintegrated, is observed at *Wheal Jewel*,‡ it is thick lamellar, and the cleavage dips towards the east. At *East Wheal Damsel*§ the rock is somewhat similar, but harder, less decomposed, and with a deeper tint of blue: from this place through Carharrack, *Ting Tang*,‖ and along the south flank of Cairn Marth, a brick-red and decomposing micaceous slate prevails† at the surface, until it joins the slaty schorl-rock at *Wheal Beauchamp*:¶ whilst, at no great depth beneath it, occurs a greyish-white slate which is very soft and friable.

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* "The only heaps of slate that I saw here, were in a state of disintegration, "and of a dark red colour: but even in this state it is evidently different from "that around Chasewater, being full of dark coloured spots resembling that of "Cligga, and other places adjacent to the granite. That part of the mine, next "to St. Day, is in another kind of rock, compact felspar, which is like that at "Wheal Coates, and is abundantly intermixed with granitic *elvans*. A hard "and very tough rock, of a purplish colour, immediately succeeds the last; it "breaks into thick laminæ, the surface of which is copiously studded with "minute shining particles. It appears to be a variety of compact felspar, "laminated by minute scales of mica, or some such mineral."

DR. BOASE, *Cornwall Geo. Trans.* IV. p. 306.

† "In a part of the parish of Gwennap there is a stratum of reddish killas "which underlies very rapidly; in some parts it is not more than two or three "fathoms deep, but in others it extends to the depth of forty fathoms: the "lodes regularly intersect this stratum; but the copper lodes are invariably un-"productive in it: tin has been found in it, but not plentifully."

MR. CARNE, *Cornwall Geo. Trans.* III. p. 81.

‡ Table LXV. § Table LXIV. ‖ Table LX. ¶ Table LVIII.

Wherever the nature of the surface will permit, similar varieties of slate are seen in Gwennap-moors, and near Trevarth and Comfort; but a greyish buff-coloured slate prevails at *Wheal Squire*, and towards *Poldory** it passes into a pale blue: this rock continues through *Ale and Cakes*,* the eastern part of the *Consolidated Mines*,† and the *Union Mines*.‡

In all these cases it, however, assumes a darker hue at greater depths; and, generally speaking, the *lodes* are less productive in this deep blue slate than when lighter tints prevail.§

The western parts of the *Consolidated Mines*‖ are worked to smaller depths, and there the slate is generally very soft and of a pale dove colour: but, towards *Poldory*,* it passes into a laminated schorl-rock, like that of *Wheal Beauchamp*.¶

The cleavage dips towards the south-east, with but very few exceptions.

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* Table LXI. † Table LXIII.

‡ A Paper of my own—Cornwall Geo. Trans. III. p. 203.

§ "The killas, when below the surface is mostly very hard, and principally "of a bluish colour; but when near the surface it is generally light brown; in "some places it is white, or nearly so, and occasionally a faint red."

MR. THOMAS, "*Report*," p. 18.

‖ "The Consolidated and United setts are almost entirely composed of "'killas,' or primary clay slate, resting immediately on the granite of Carn "Marth, which, at the western extremity of the sett, dips below the killas at a "considerable angle, appearing to vary from about twenty-five to thirty "degrees. The colour of the killas near the surface is generally brownish, "with occasionally a tinge of red; in depth, a dull or blueish grey is most "common, but it is often white, or nearly so, particularly in the United Mines. "The texture of this rock is generally fine grained and slaty; and its stratifi-"cation, if that term can be applied to the slaty cleavage which it presents, is "often highly inclined, and appears to have a tendency to conform with the "underlying body of granite; but, in this respect it is by no means regular. "The killas is generally of only a moderate degree of hardness."

MR. BURR, *Mining Review*, No. VII. (July, 1835.) p. 20.

¶ Table LVIII.

Towards the eastern part of *Poldice*, and south of the parts of that mine at present worked, a deep pink-coloured slate appears: its laminæ are rather thick, with a cleavage inclining towards the south-east, and joints bearing 25° S. of W.

At Creeg-braws Common the slate, near the surface, is generally of a pale buff, which passes into a light pink colour; but, from the appearance of the mine heaps, it may be presumed that a deep blue slate prevails below. At Kerley Downs, and on Ball-due Common, the case is similar, and at Twelve-heads a deep blue slate occurs, and is continued on both sides of the valley as far as Chasewater; it is in very thick beds, and the cleavage inclines towards the south-east, whilst the principal joints bear about 20° W. of N.

Throughout *Chasewater Mine** the slate is of a

* "On Friday the 15th of July, 1757, a violent shock of an Earthquake was "felt in the Western parts of Cornwall.

"The Thermometer had been higher than usual, and the weather hot or calm, "or both, for eight days before; wind East and North-East. On the 14th, in "the morning, the wind shifting to the South-West, the weather calm and "hazy, there was a shower; the afternoon hazy and fair, wind North-West; "the Barometer moderately high, but the Mercury remarkably variable.

"On the 15th, in the morning, the wind was fresh at North-West, the at-"mosphere hazy, being on the sands, half a mile East of Penzance, at ten a. m. "near low-water, I perceived, on the surface of the sands, a very unusual in-"equality; for whereas there are seldom any unevenesses there, but what are "made by the rippling of the water, I found the sands, for above a hundred "yards square, all full of little tubercles (each as large as a moderate mole-"hill), and in the middle a black speck on the top, as if something had issued "there; between these convexities, were hollow basons of an equal diameter; "from one of these hollows, there issued a strong rush of water, about the big-"ness of a man's wrist, never observed there either before or since.

"About a quarter after six, p. m. the sky dusky, the wind being at West-"North-West, fell quite calm; about half past six, being then in the summer-"house at Keneggy, the seat of the Honourable J. Harris, Esq., near Penzance, "with some company, we were suddenly alarmed with a rumbling noise, as if

pale grey, but towards *North Downs* it passes into a bluish-white occasionally streaked with brown.

"a coach or waggon had passed near us over an uneven pavement; but the "noise was as loud in the beginning and at the end, as in the middle, which "neither the sound of thunder or of carriages ever is: the sash casements "jarred; one gentleman thought his chair moved under him, and the gardener, "then in the dwelling-house, (about a hundred yards distant from us) felt the "stone pavement of the room he was in, move very sensibly.

"In what place the shock began, and whether progressive or instantaneous "in the several places where it was felt, is uncertain, for want of accurately "determining the precise point of time in distant places.

"The shock was not equally loud or violent. Its extent was from the isles "of Scilly Eastward as far as Liskerd, and towards the North as far as Camel-"ford; through which district I shall trace it according to the best informations "I could procure.

"In the island of St. Mary, Scilly, the shock was violent: on the shores of "Cornwall, opposite to Scilly, (in the parish of Senan, near the Land's End) "the noise was heard like that of a spinning-wheel on a chamber floor: below "stairs, there was a cry that the house was shaking; and the brass pans and "pewter rattled one against another in several houses in the same parish. In "the adjoining parish of St. Just, two young men, being then swimming, felt "a strong and very unusual agitation of the sea. In the town of Penzance, "in one house the chamber bell rung, in another the pewter plates, placed "edgeways on a shelf, shifted, and slid to one end of the shelf; and it was "every-where perceived more or less, according as peoples attention was "engaged.

"At Trevailer, the Seat of William Veale, Esq., about two miles from Pen-"zance, the noise was heard, and thought at first to be thunder: the windows "shook, and the walls of the parlour, where Mr. Veale sat, visibly moved. "The jarring of the windows continued near half a minute, but the motion of "the walls not quite so long; and some masons being at work on a contiguous "new building, the upright poles of the scaffolds shook so violently, that for "fear of falling, they laid hold on the walls, which, to their still greater sur-"prize, they found agitated in the same manner; and a person present, who "was at London at the time of the two shocks, in the year 1751, thought this "shock to resemble the second, both in degree and duration.

"At Marazion, the next market town East of Penzance, the houses of "several persons shook to that degree, that people ran out into the street, lest "the houses should fall upon them. In the borough of St. Ives, on the North "Sea, six miles North of Penzance, the shock was so violent, that a gentleman "who had been at Lisbon during several shocks, said, that this exceeded all he "had met with, except that on the 1st of November, 1755, so fatal to that city.

"At Tehiddy, the Seat of Francis Basset, Esq., the rooms shook, and the "grounds, without doors, were observed to move. The shock was felt sensibly "at Redruth, St. Columb, Bodman, &c. along to Camelford, which is about "ninety miles from the isles of Scilly. From Marazion, Eastward, it was felt "at several places, in like manner, as far as Lostwythyel: but at Liskerd,

In some spots it contains a few thin beds of a darker colour; but the whole rock is very soft and much decomposed.* At *Wheal Chance* a mottled lead-coloured slate gradually passes into the rocks which

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" about ten miles East of Lostwythyel, it was but faintly perceived, and that " by a few persons: it was still less sensible at Loo and Plymouth, ' scarcely " ' sufficient to excite curiosity or fear.'

" The times of its duration were various. At Keneggy, we thought the " noise could not have lasted above six seconds; at Trevailer, not two miles " distant to the West, it was thought to have lasted near half a minute; in the " parish of Gwynier, half a minute; at Ludgvan, three miles East of Pen- " zance, the noise was rather longer than half a minute; but the shaking felt " in the garden, and observed in the houses, short and momentary. In Germo " great-work, seven miles east of Penzance, it lasted only a few seconds; but " in the isles of Scilly, it was computed at forty seconds.

" So was this Earthquake felt in towns, houses, and grounds adjacent; but " still more particularly alarming in our mines, where there is less refuge, and " and consequently greater dread, from the tremors of the earth.

" In Carnorth Adit, in the parish of St. Just, the shock was sensibly felt " eighteen fathom deep; in the mine, called Boscadzhil-downs, more than " thirty fathom.

" At Huel-rith mine, in the parish of Lannant, people saw the earth move " under them, first quick, then in a slower wavy tremor; and the stage boards " of the little winds or shafts, twenty fathom deep, were perceived to move.

" In Herland mine, commonly called the Manor, in the parish of Gwynier, " the noise was heard fifty-five and sixty fathom deep, as if a *studdle* had broke " and the *deads* were set a running: It was nothing like the noise of thunder.

" In Chace-water mine, the same noise was heard, at least seventy fathom " under the surface.

" At Huel-rith mine, near Godolphin, the noise was seemingly underneath. " I felt (says the director of the mine) the earth move under me, with a pro- " digious swift, and apparently horizontal tremor; its continuance was but for " a few seconds of time, not like thunder, but rather a dull, rumbling, even " sound, like deads running under ground. In the Smith's shop the window- " leaves shook, and the slating of the house cracked; the Whim-house shook " so terribly, that a man there at work ran out of it, concluding it to be falling. " Several persons then in the mine, working sixty fathom deep, thought they " found the earth about them to move, and heard an uncommon noise: some " heard the noise, and felt no tremor; others, working in a mine adjoining, " called Huel-Breâg, were so frightened, that they called to their companions " above to be drawn up from the bottoms: their moorhouse was shaken, and " the padlock of their candle-chest was heard to strike against the staples."

DR. BORLASE, *Natural History of Cornwall* (1758), pp. 55–58.

* Table LXIX.

have been already described as in contact with the granite.*

At *Wheal Harmony* occurs a bed of slate, quartzose and intensely hard,† but of no great thickness. In general it is massive, and often consists almost wholly of quartz. It is probably the easterly *thinning out* of the greenstone beds which have been previously mentioned.‡

The *elvan-courses* are unusually numerous in this district. The most northerly one is on the north of *Wheal Peever*,§ and may be traced across the common as far eastward as *North Briggan* where it has been quarried; it dips N. 40–50°, and is from 6 to 8 fathoms wide. The next *elvan* has been extensively worked in several places, as at Treleigh, north of Redruth, and passes eastward through *Cardrew Downs*‖ and *Treskerby*;¶ it is from 8 to 10 fathoms wide, and dips S.: at *Cardrew Downs* it sends *offshoots* into the slate.

The third *elvan* appears in the Hayle Railway *terminus* at the western end of Redruth, and is there 7 fathoms wide and dips S. It passes under the town, and is again seen about a mile eastward near the toll-gate, where it is worked for road-stones. In this last-mentioned locality it appears in the granite,

* *Ante*, p. 74.

† "A course of detached iron-stone rocks, somewhat inclining to killas and "interspersed with quartz, traverses Cardrew Mines, in a line from the south "part of Wheal Harmony to Wheal Prussia." MR. THOMAS, *Report*, p. 18.

‡ *Ante*, p. 61.

§ Mr. John Williams, Jun., Geo. Trans. IV. p. 143, Pl. VII. fig. 1. Mr. Thomas, Report, p. 31.

‖ Table LXVIII. ¶ Mr. Carne, Cornwall Geo. Trans. II. Pl. III. fig. 15.

through which I have been unable to trace its further progress towards the east.—

All these occur on the north of the Cairn Marth granite.

The fourth *elvan-course* is seen in the adit north of *Wheal Buller*,* and again, at 69 fathoms deep, in the western part of the same mine (*b*), both west of Cairn Marth: it is about 25 fathoms wide, and dips N. 40-50°. Near *Davey's lode* its joints contain large quantities of native copper; and, in some places, there is a gradual transition between the *lode* and the *elvan*, through the medium of a quartzose, and fine grained, but still porphyritic, rock, which is often impregnated with copper pyrites, sometimes in veins, and at others in small unconnected masses.

Another *elvan-course* is observed in *Wheal Beauchamp* engine-shaft (*a*).† At the depth of 29 and 42 fathoms; it is only 3 fathoms wide, whilst at 69 fathoms deep its breadth is 30 fathoms: from it several veins *shoot* into the slate, and frequently to considerable distances.

On the top of Lanner Hill an *elvan* appears in the water-course at the side of the turnpike-road; and a little south of *Wheal Buller* counting-house a similar rock, within the borders of the granitic tract, is very largely quarried for building purposes,

On the eastern side of the Cairn Marth granite and south of *Treskerby*, the most northerly *elvan* appears in the side of the hill which rises north of

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* Mr. Thomas, Report, p. 50. Table LVIII. † Table LVIII.

the valley leading to *Wheal Pink*, and again in *Wheal Unity Wood*, and is there called *the great elvan*.* It is probably the same which has been used in building great part of Chasewater, and which is extensively worked at Creeg Quarry, on Creeg-braws Common; and, passing very near Chasewater Church, re-appears on the east, about midway between Kerley-barrow and the turnpike-road. It dips N. 30–40°, and is from 6 to 8 fathoms broad.

The next *elvan-course* passes through *Wheal Unity* and *Poldice*, is intersected by many of the workings of *Creeg-braws*, and is here and there exposed in small quarries on the common.† Further eastward it passes directly under Kerley-barrow, where it opens in thick-flaggy horizontal beds, and is largely quarried. Its dip appears to be S., and its breadth 3 or 4 fathoms.

The uncertainty attending the relations of the *elvans* in Coisgarne Downs has been frequently

* Table LXVI. This *elvan* has here been extensively worked for the tin ore with which it is abundantly sprinkled throughout.

"A little south of Chasewater, at Creag Braws, a *course of elvan* has been "extensively quarried in the direction of the bed: it runs nearly east and west, "and dips northward, at about 40°, as is shewn about the middle of the quarry, "where the *elvan* is seen in contact with the slate, which is red, and much dis-"integrated. This *elvan* is a felspar-porphyry, varying, as usual, in different "parts of the bed: some of its layers have a basis of grey compact-felspar, "containing white decomposed felspar, which is rarely in distinct crystals: "the greater part of this *elvan*, however, has only imbedded granules of quartz, "and numerous crystalline groups of a dark mineral, which decomposes into "ochreous spots. The upper part of this *elvan* has acquired a yellow colour, "and is completely disintegrated." DR. BOASE, *Corn. Geo. Trans.* IV. p. 305.

† Mr. Thomas, Report, p. 66.

In one of these quarries it apparently dips S., and is *thrown* 3 feet upward by a joint traversing both the *elvan*, and the contiguous slate. The junction of the two rocks is very distinctly displayed.

pointed out;* and although I have devoted much time to their examination, I must give the following results of my enquiries with some hesitation. The leading facts are well ascertained: but respecting a few minor details which are not equally evident there may be some difference of opinion.

Four *elvan-courses* are seen to traverse Coisgarne Downs. The first appears near the Devron Railway, where it crosses the high-road at *West Wheal Virgin*, and again in the eastern part of *Wheal Virgin*.† It crosses the valley near Hayle Mills, as marked in Mr. Thomas's Maps,‡ and afterwards that which runs from Twelve-heads to Chasewater: it is found also at Skit's Coombe, *Wheal Hope*, south of *Wheal Sperris*, and on the north-east of *Wheal Falmouth*.§ Nowhere can its size be well ascertained: it is, however, several fathoms wide, and dips N.

The second of these *elvan-courses* may be traced on the common between *West Wheal Virgin*|| and *Ale and Cakes*:¶ it next appears at from 80 to 90 fathoms deep in *Wheal Lovelace (Consolidated Mines)*,|| and also near *Pearce's Engine*, at 180, and in another place (west) at 200 fathoms deep: also in *Wheal Fortune* at 160 and 200, and in *Cusvey (Consolidated Mines)*** at 160 fathoms deep. At

* Mr. Thomas, Report, pp. 17-67, and Mining Review, No. VIII. (May, 1836) p. 269. Mr. Carne, Cornwall Geo. Trans. II. p. 82. Mr. Burr, Mining Rev. No. VII. (July 1835) pp. 22–25, & Elements of Practical Geology, p. 287.

† Table LXII.

‡ Geological Map of the Mining District of Cornwall (1819), and Maps of the Carn Menelis District (1833), in the Museum of the Royal Institution of Cornwall.

§ Table LXVII. || Table LXII. ¶ Table LXI. ** Table LXIII.

Wheal Friendship it occurs at the surface, and it may be traced eastward through *Nangiles*,* *Ball-due*, *Wheal Tregothnan*, Goodern, Venton-goose, and further eastward it crosses the vale north-west of Penwethers. At *Wheal Fortune*, *Cusvey*,† *Wheal Friendship*, and *Ball-due*, it dips N. 30–45°. At the first mine it is about 20 fathoms wide, and in the last about 16.

The third of these *elvan-courses* may be traced nearly to the granite of Cairn Marth, on the north of Roche's Engine at *Ting Tang*;‡ and thence across the common to the White-works north of *Poldory*,§ where it was formerly wrought for the large quantity of tin ore it contained. Latterly the decomposed portions have been removed for the manufacture of a coarse, but useful, kind of fire-brick, and to be employed as fire-clay for the lining of furnaces, and setting the fire-places. The rise of the hill eastward throws its *back* southward, and it re-appears in a water-course south of *Ale and Cakes*,§ and again in that mine at 148 fathoms deep. But in these localities its size is very irregular; indeed, in the last mentioned it is only a few feet wide, and sends off *shoots* and veins into the contiguous slate. Eastward it re-appears on the declivity of Race-hill, and again not far from the mouth of the great adit. In one of the Devron Railway-cuttings it is exposed,

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* "In this mine, adjoining to the north side of the lode, is a course of soft "white elvan, 30 fathoms in breadth, and on the south side of the lode killas."
MR. THOMAS, *Report*, p. 38.

† Table LXIII. ‡ Table LX. § Table LXI.

and may be traced thence across the common towards *Wheal Whidden*, and is well shewn in a deep rut about 200 fathoms south of *Tregothnan Consols*. Throughout its course the superficial portions are much decomposed. It everywhere dips N.; and, with the exception already mentioned, is from 10 to 12 fathoms wide.

The last *elvan* which I have noticed thus at length, appears near Trevarth, and is met with in the workings of *Ting Tang*,* south of which, and near the road from Carharrack to Comfort, the decomposed superficial parts are now used for the manufacture of fire-bricks. It may be traced throughout the workings of *Wheal Squire*, at the surface to the south of *Poldory*,† and again, at 173 fathoms deep, in the engine-shaft of that mine, and thence across the vale to Sunny-corner, through the enclosures at Coisgarne, and crosses the great adit near Point-stamps. It is found again at *Bissoe Bridge Mine*, where much tin ore has been obtained from it: thence it may be followed along a line of old but shallow workings extending over the common to *Wheal Bottrall*, and to the south-east of Sparnick. This *elvan* dips N. 40-50°, and is many (in the adit at *Ting Tang** 24) fathoms wide: like the preceding it is often much decomposed near the surface. Of all of them it may be remarked that, in many parts of their course, they are largely quarried for building materials.

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* Table LX. † Table LXI.

Traces of *elvan* present themselves in the way-side north of Comfort, and in two or three places in the adit east of *Tresavean*,* but these are probably portions of other courses which lie to the south of those already mentioned.

The hill on the western side of the valley which separates the parish of Redruth from that of Illogan has been partly cut down, and in the section of slate rock thus exposed is an isolated patch of a porphyritic felspar rock, which looks like an unconnected mass of *elvan*; it is, however, far from any *elvan-course*, and also from the granite of Cairn Brea.

In their directions the *elvan-courses* are about 10–20° S. of W., but vary a little in different places: and they differ from those in most other districts, inasmuch as they bear much less to the south of west than the *lodes*; and, with the exception of that observed at the Hayle Railway-station at Redruth, the *Cardrew Downs*† *elvan*, and the south *elvan* on Creeg-braws, they all dip towards the north.

They are commonly several fathoms wide; and their composition is similar to that of the *elvan-courses* already described;‡ viz., a basis of compact felspar, usually of a greyish-buff, or a pale pink hue, mixed with some siliceous matter, and generally containing masses of crystalline felspar, and often, too, double-pointed crystals of quartz: schorl not unfrequently appears in radiating crystalline groups,

* Table LIX. There are several *elvan-courses* at no great distance southward of this mine.

† Table LXVIII. ‡ *Ante*, pp. 31–37–51–64.

and ferruginous matter is very largely dispersed through them.

These *elvan-courses* abound in irregular joints, and have often a somewhat concretionary structure, evidently dependent on the mode in which the ferruginous particles are distributed: these at one time take a globular, and at another an angular form; around these concretions the rock is also often decomposed, as at the Hayle Railway *terminus* in Redruth.

The colouring matter on the surface of these *elvans* seems, in some measure, to depend on that of the contiguous rocks, since the hues will vary from a rusty red to pale grey, in the same course, and even within very short distances, as at Treleigh and Creeg-quarry.

Of all these the junctions with other rocks are well shewn in many situations: in some cases there seems to be a gradual transition from the *elvan* to the massive slate rocks in contact, as at the *Consolidated** and the *United Mines*;† in others, as at the White-works, Creeg-braws, &c., the line of demarcation between them is distinctly marked.

I have already mentioned the mode in which tin ore is dispersed through them at *Wheal Unity Wood*,‡ White-works, and Bissoe-bridge, as well as the decomposed state of some of their superficial portions, and also the purposes to which these have been applied. Indeed the rubbish thrown up on the

* Tables LXII. LXIII. † Table LXI ‡ Table LXVI.

surface of the mines, whether it be from slate, *elvan*, or granite, everywhere decomposes so very rapidly, that no portions of it, but those which are quartzose and have been obtained near the *lodes*, are fit for building-stones.

The average bearing of the *lodes* in this district varies from 15-30° S. of W.; their usual dip is towards the north, though with numerous and important exceptions.*

There are here many *cross-courses* and *cross-flucans:* the most considerable enters the district at *North Downs*,† where it *heaves* the *lodes* 54 fathoms towards the right hand, whilst a second, within a few fathoms in the same mine, *heaves* them again in the same direction 18 fathoms.‡ These *cross-veins*, most probably, unite southward of this mine, but their further course in that direction is not certainly known. On the opposite side, however, of the eastern portion of the Cairn Marth granite, certain *flucans* occur, which are thought to be splits and branches of the great *cross-course*. In the range of these *flucans* southward, through *Wheal Damsel*,§ *Wheal Jewel*,‖ *East Wheal Damsel*,¶ *Ting Tang*,**

* *Taylor's Lode*, at the *Consolidated Mines*, in general dips N., but the deeper parts of the most easterly portion yet seen have an opposite inclination.

† Table LXIX.

‡ Mr. John Williams, Jun., Geo. Trans. IV. p. 142, Pl. VII. fig. 1. Mr. Thomas, Report, p. 28. Mr. Carne, Cornwall Geo. Trans. II. p. 109, Pl. II. fig. 3. Mr. Hawkins, Ibid, p. 239.

The *cross-courses* are composed of an infinity of small veins, each of which *heaves* the *lode* a small distance.

§ Mr. Wm. Phillips, Geo. Trans. O.S. II. p. 156, Pl. VI. fig. 1. Mr. Thomas, Report, p. 52.

‖ Table LXV. ¶ Table LXIV.

** Table LX. Mr. Carne, Cornwall Geo. Trans. II. p. 116, Pl. II. fig. 11.

Wheal Squire,* and *Poldory*,† some *heave* the *lodes* towards the right hand, but perhaps the greater number do so to the left. Nothing, indeed, can be more irregular than the way in which the *lodes* are affected by innumerable little *flucans* in *West Wheal Virgin*,‡ *Poldory*,† and *Wheal Squire*;* which mines occupy a tract bounded on the west by a *flucan* or *cross-course* separating the latter from *Ting Tang*,§ and on the east by *Tiddy's cross-course*, which divides *Ale and Cakes* from *Poldory (United Mines)*.†

These small *flucans* often extend but a few fathoms in either direction, and occasion, as it were, rents in the middle of the *lodes*, neither rising to the surface, nor descending to any great depths: in their results they may be compared to rents in the middle, but which do not reach to the edges of a piece of cloth.||

There are, however, several principal *flucans* observing much regularity both in their bearing and effects. Some such occur in *Wheal Damsel*¶ and *Wheal Squire*,** mines now no longer worked, which therefore I have not explored: other *flucans* in other of the mines are still accessible.†† One of

* Mr. Thomas, Report, p. 64. Mr. Carne, Cornwall Geo. Trans. II. p. 116, Pl. II. fig. 7. † Table. LXI.

‡ It was by one of these that the *heave*, which has been already described by me (Cornwall Geo. Trans. III. p. 329), was effected. In the severed portions of the *lode* were two quartz stones which, on comparison, exactly fitted into each other; and the intervening *flucan* contained a cavity corresponding with their irregularities.

§ Table LX. Mr. Carne, Cornwall Geo. Trans. II. p. 116, Pl. II. fig. 11.

|| This seems also the case in *Wheal Buller* and *Wheal Beauchump* (Table LVIII.); for the *cross-veins* affecting one *lode* do not meet the others.

¶ Mr. Wm. Phillips, Geo. Trans. o.s. II. p. 156, Pl. VI. fig. 1. Mr. Thomas, Report, p. 53. ** Mr. Thomas, Report, p. 64.

†† *East Wheal Damsel, Wheal Jewel, Poldory, &c.*

the chief of these, called *Stevens's flucan*, in *East Wheal Damsel*,* and *John's flucan, in Wheal Jewel*,† in the former *heaves* the *lodes* from 6 to 12 fathoms, and from 5 to 12 fathoms in the latter, and in every instance towards the left: whilst in the former, another *flucan heaves* the *lodes* 12 fathoms to the right hand.

At *Poldory*,‡ *Skues's flucan heaves* all the *lodes* south of a given line, towards the right, and all to the north of it, to the left hand: but all these which are nearest to this assumed line of separation are *heaved* to greater distances than those which are further from it. In the same mine, *Bawden's flucan heaves* the *lodes* from 8 to 10 fathoms towards the right.

Tiddy's cross-course passes through *Wheal Unity, Poldice,* the *Consolidated*,§ and the *United Mines*.‡ In the *Consolidated Mines*§ it *heaves* the *lodes* from 2 feet to 2 fathoms, and always to the right hand: in the *United Mines*‡ the *heaves* are from 6 to 8 feet, and though they are rather more frequently towards the left, yet, in one singular case, the same *lode* is *heaved* by the same *cross-course* to the right at one spot, and at another towards the left.

But, although the *lodes* traverse the rocks which lie between the *elvan-courses*, and sometimes also

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* Mr. Hawkins, Cornwall Geo. Trans. II. p. 229, Pl. IV. fig. 1. Table LXIV. Mr. R. W. Fox, Phil. Trans. (1830) pp. 410–414, fig. 8–25.

† Table LXV. Dr. Boase, Primary Geology, p. 181, fig. 17. Mr. R. W. Fox, Phil. Trans. (1830) pp. 409–414, fig. 1–2–26.

‡ *United Mines*, Table LXI. § Table LXII.

even the *elvans* themselves,* and though the *cross-courses* and *flucans* traverse *lodes*, *elvans*, and other rocks, alike and indiscriminately, and though the *lodes* are almost invariably *heaved* by these *cross-veins*, yet within the whole tract, as far as I am aware, there is not a single case of an *elvan* which is *heaved* by either of these veins.†

Of two series which thus irregularly alternate with each other, and are both intersected by a third system of veins, the first is displaced, whilst the second remains unmoved: though the second is invariably cut through by the first whenever they meet.

The *cross-courses* and *cross-flucans* generally bear W. of N., on an average perhaps, about 20°, but some range even S.E. and N.W., whilst a few *strike* obliquely as far as N.E. and S.W. They often descend more perpendicularly than the *lodes*, but, whenever inclined, the greatest number dip eastward.

The difference between *flucans* and *cross-courses* is merely in their contents: the former consists chiefly of clay, but the latter contains quartz also, which is frequently disposed in veins, or exhibits a jointed structure. Such veins of crystalline quartz

* Mr. Michael Williams is of opinion, that in this district the *lodes* which intersect *elvan-courses* in their descent, are seldom productive beneath them.

† "On the sea-shore a little west of Swan Pool, is a large *elvan-course*, "which runs about north-east and south-west, for several hundred feet, and "dips east of south at an angle of 45°. Near low water-mark it abruptly "terminates; but immediately adjoining, on the southern side, it is seen con-"tinuing its course in the original direction, so that it has apparently been "moved about twenty feet." Dr. Boase, *Cornwall Geo. Trans.* iv. p. 315.

Mr. Thomas, Mining Review, No. viii. (May, 1836) p. 275. Dr. Boase, Primary Geology, p. 54.

This is, however, some miles south of the limits of this district.

compose the larger part of the *great cross-course*,* of *Tiddy's cross-course*,† and of many in *North Downs*.‡ But other parts of the same veins are principally of clay, in which case they are recognized as *flucans*.

This district illustrates the difference which takes place in the contents of veins whenever they pass from one kind of rock to another. Of this fact the *cross-courses*, perhaps, afford the most conspicuous examples: as whether they traverse slate, *elvan*, or granite, their characters immediately alter with the change in the containing rock.§

Little valuable produce has been found in the *cross-veins* of this district. At *West Wheal Virgin (Consolidated Mines)*,‖ vitreous copper ore, red oxide of copper, and native copper, have been found in a few rich *bunches* in *Tiddy's cross-course*; in *Ting Tang*¶ a vein of vitreous copper ore, of 2 feet wide, accompanies the *western flucan* for the whole distance (3½ fathoms) between the portions of the *middle lode*, which it divides; and, at *Wheal Sparnon*, cobalt has occurred in a *cross-course*.**

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* *Ante*, p. 88. † Tables LXI. LXII. ‡ Table LXIX.

§ "The soft bluish-white killas is most favourable to copper, and the hard "black killas to mundic: the change in the lodes in passing through strata of "both descriptions is frequently from copper to mundic. In general an un-"favourable change takes place in both copper and tin lodes when the killas "becomes very slaty, although not harder than before."

MR. CARNE, *Cornwall Geo. Trans.* III. p. 82.

‖ Table LXII. ¶ Table LX.

** Mr. Thomas, Report, p. 63.

"We have had but one Cobalt Mine that ever was distinguished by that name "in this vicinity, which was discovered accidentally by Mr. Beauchamp, in an "adit that he drove through some part of his estate at Pengreep in Gwenap. "He discovered a lode of three feet in breadth, which contained a branch of

For the most part, the produce of the *lodes* is copper pyrites, which is raised in every mine in the district in very large quantities: vitreous copper ore has, however, been plentiful in *Wheal Jewel, East Wheal Damsel, Ting Tang*, &c., and native copper and the red oxide of copper have been abundant in *Wheal Gorland, Wheal Unity, Ting Tang, Wheal Buller,** *Penstruthal*, &c.; the carbonates, arseniates, and silicates of copper, and other combinations of the same metal, have also prevailed in several of the mines just mentioned.

Near the surface, the *lodes*, with few exceptions, contain much earthy brown iron ore, mixed with quartz *(gossan)*,† and interspersed with black and vitreous copper ores, blende, galena, and also with tin ore.‡ It is indeed worthy of remark that the shallower parts of several have produced tin ore in

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" real Cobalt; and it happening about the time when the Society of Arts, &c., " offered a premium of thirty guineas for the best Cobalt to be discovered in " England, he was honoured with the reward for his specimen, pursuant to the " advertisement. It did not hold in depth, but soon deserted the pursuers."

MR. PRYCE, *Mineralogia Cornubiensis*, p. 50.

* In this mine vitreous copper ore and copper pyrites occur *mixed*, in very large quantities.

† " On fait une distinction en général des matieres qui accompagnent & " annoncent ces deux especes de minérais; celles qui forment les filons de " cuivre qui conduisent au minérai, & qui en contiennent souvent elles-mêmes, " se nomment *gozan* ou *gossan:* près de la surface de la terre, c'est une espece " de minérai de fer en partie décomposé, ou substance ocreuse unie à du quartz " & à un rocher bleuâtre; mais dans la profondeur ce *gozan* est composé de " quartz & de mica blanc sur une roche d'un bleu clair, assez souvent avec de " la pyrite jaune ou blanche, quelquefois aussi le tout est parsemé de minérais " de cuivre." M. JARS. *Voyages Métallurgiques* (1765), III. pp. 192–193.

‡ " Our Gossan Lodes often produce Tin at a shallow level in tolerable plenty; " and chiefly that Gossan which is of the most ferruginous stamina."

MR. PRYCE, *Mineralogia Cornubiensis*, p. 44.

considerable quantities; whilst, at greater depths the same veins have been prolific of copper ores.

Much tin ore* has been obtained at *Poldice, Wheal Unity Wood,* and *Ball-due.*

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* There are but two manufactories of white arsenic *(arsenious acid)* in the kingdom, and both of them are in this neighbourhood: the first, established about 25 years since, near Perran-well; the other, within 2 or 3 years, near Bissoe-bridge. The materials which are procured from all parts of Cornwall, consist of sulphur and arsenic, mixed in various proportions, and are obtained from the flues of the ovens in which the ores of tin and copper are roasted, in order to facilitate their separation.

They are first placed in a common reverberatory furnace, having a very long flue, and the heat is so slowly increased as to dissipate the sulphur before the arsenic is volatized. The temperature is then carefully raised and the arsenic is driven off: but as this requires a much greater heat than the sulphur, it is therefore the more readily deposited on the sides of the flue. When this has been continued for a sufficient time, perhaps weeks, or even months, the fire is extinguished, the flue is opened, its contents are removed, and the finer part of the arsenic is found next the fire: as the distance therefrom increases, the arsenic is found more and more mixed with sulphur, and this is again placed in the furnace for a repetition of the first process.

The purer portion is now introduced through a hole at the apex into conical cast-iron retorts of about 2½ feet high, and from 15 to 18 inches in diameter at the base. The broader ends of these are clamped to an iron plate, which forms the upper side of a flue from a rather small but very brisk fire, and the joints are closed by luting; the aperture at the top being shut by a plain iron stopper only. When the workman thinks that this has been all sublimed, he removes the plug, and through a funnel introduces a further charge, and so on until he imagines a sufficiently thick crust is deposited within: the clamps are then taken off, the retort is conveyed into the open air, and its place supplied by another. These, whilst at work, are placed beneath a dome opening into the external air, in order that the labourers may not be injured by the mixture of the vaporized arsenic with the atmosphere of the work-shop.

The pure white arsenic thus lining the retort is usually about an inch thick, and is very easily removed: it is of a pale amber colour, and in that state large quantities are sold; sometimes, however, it is reduced to powder, and this is done in a grist mill of the ordinary kind.

This method is essentially different from the German mode, described by Mr. Vivian, Cornwall Geo. Trans. I. p. 61.

All attempts to prepare orpiment and realgar here have been fruitless; and experiments on the extraction of arsenic, directly from the arsenical pyrites, have been, in point of economy, equally unsuccessful.

It is not easy to ascertain the quantity of arsenic manufactured in Cornwall: in 1826, 83 tons were shipped at Penryn (Cornwall Geo. Trans. III. p. 360): at present I believe not less than from 600 to 800 tons are prepared annually, and this from substances which 30 years since were thrown away as useless.

Arseniate of lead has been found finely crystallized in *Wheal Unity;* uranite in *Wheal Buller* and *Carharrack;* fluor in *Wheal Unity Wood, Poldice, Wheal Gorland,* &c.; mineral pitch in *Treskerby,* and *East Wheal Damsel;* and in other of the mines, many rare and curious minerals.

Wheal Buller and *Wheal Beauchamp* are worked in a patch of slate, having granite both on the east and west, and the ore in the *lodes* has little or no prevailing dip: all the other mines in the district are, however, on the east of the granite, and the *shoots* of ore are all inclined towards the east. It is, moreover, not unworthy of remark, that the mines in the south part of the district have hitherto been found productive at greater depths than those on the north; and in this respect a sort of gradation seems to prevail from *Wheal Towan,* and the other mines on the borders of the Bristol Channel in the Saint Agnes district, through *North Downs, Wheal Unity,* and *Poldice,* to the *Consolidated* and *United Mines* on the southern boundary of the tract.

The occurrence of the richer portions of parallel *lodes* on the same meridian* has been long known and acted on; and, indeed, seems to have been first recognized in this district.

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* "It is commonly believed that wherever a lode is rich, if there be another "lode near it, having nearly the same direction, and in the same *country,* whe- "ther killas or grouan, or even in an elvan-course, it is probable that the second "lode will be found rich in that part which is opposite to the rich part of the "first lode. This is not a new doctrine: the phrase *ore against ore* is probably "of earlier date than the present generation of miners."

MR. CARNE, *Cornwall Geo. Trans.* III. p. 78.

The mines of this neighbourhood are not only the most extensive* and productive† in the county, but they are also the deepest,‡ and the machinery employed on them is of the most powerful description: and as all the water is drawn up by steam-engines, it is an important object to discharge it from the

* It appears that in the *Consolidated Mines* alone, within 20 years (ending June, 1838), about 37,330 fathoms have been *driven* horizontally, and about 18,000 fathoms *sunk* in *winzes* and shafts; being a total of nearly *sixty-three miles*. Mr. Taylor's "Reply to Observations on the Statement of the Committee of the Consolidated Mines Adventurers" (1838); printed for private distribution.

† "The (Consolidated) Mines commenced working in June 1819, and at the "end of 1837 the account exhibited the following results:—

"Quantity of ore raised and sold — — —	259,420 Tons
"The value of which was — — — —	£1,845,326
"Paid to the Lords (of the land) as dues — —	£ 76,888
"Cost of working the mines — — — —	£1,450,836
"Of which was paid for labour only — — —	£ 758,590
"And the profit paid to the adventurers, besides the "return of their capital (£65,000) — — —	£ 248,000."

Statement of the Committee of the Consolidated Mines Adventurers, p. 6.

I am favoured with the following abstract of the proceeds and costs on the working of *Tresavean*:—

	Value of Ores.			Dues paid the Lord.			Costs, Labour, Materials, &c.			Profit divided among the Adventurers.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1828. —	17,456	5	3 —	872	15	8 —	12,240	10	1 —	4,320	0	0
1829. —	25,813	18	8 —	1,290	13	6 —	14,518	16	0 —	10,336	0	0
1830. —	41,162	8	6 —	2,063	2	7 —	22,135	7	4 —	16,800	0	0
1831. —	57,732	6	11 —	2,891	5	9 —	26,009	14	1 —	28,520	0	0
1832. —	75,380	12	11 —	3,769	9	11 —	32,124	10	3 —	38,880	0	0
1833. —	104,396	9	11 —	5,220	14	2 —	31,375	18	1 —	60,480	0	0
1834. —	90,132	13	6 —	4,563	14	8 —	39,433	8	8 —	47,040	0	0
1835. —	74,354	0	8 —	3,771	10	0 —	39,005	5	1 —	29,760	0	0
1836. —	93,428	8	9 —	4,747	10	1 —	43,661	17	10 —	48,000	0	0
1837. —	79,794	18	3 —	4,057	2	8 —	39,041	13	0 —	32,640	0	0
1838, to Oct.	60,686	16	6 —	3,083	9	1 —	29,656	7	3 —	31,680	0	0
	£720,338	9	10	£36,331	8	1	£326,203	7	8	£348,456	0	0

There has also been a great addition to the machinery on the mine.

‡ The *Consolidated Mines* are nearly 300 fathoms deep, and the mere labour of ascent and descent is very great: many machines have been devised for raising and lowering the workmen (See Reports of the Royal Cornwall Polytechnic Society, 1834, pp. 35-42, fig. 5-6-7-8-11-12-13-14; 1835, pp. 112-113, Pl. IV. fig. 2; 1836, p. 57; 1837, p. 63, Pl. I. fig. 1.), as in the Coal Mines in the north of England, and in the German Mines; but nothing has yet been adopted.

The ladders are very irregular in position and inclination, and the distance between the ladder-staves has hitherto always been 12 inches. At *Tresavean*,

pump-head at the lowest possible level. This is attained by means of an adit* which empties itself into Carnon Valley a little above the high-water

however, an experiment which cannot be too widely known has lately been tried with complete success. The ladders are there placed at an uniform angle of 75°, and with bars 10 inches apart. By this alteration old men, who had given up working in the deeper parts of the mine, are enabled to return to work there, and to ascend and descend without the least inconvenience.

* Mr. Williams (late of Scorrier House, now of Sand Hill), informs me that this unrivalled undertaking was projected by his Grandfather, who was then manager of *Poldice*. It was commenced near Bissoe-bridge in 1748, and was extended to the western boundary of *Poldice* in considerably less than 20 years; and the expense of this portion of it was defrayed by the adventurers in that mine. It has been subsequently *driven* to the other mines which it now unwaters.

"This adit discharges its waters in the valley near Wheal Friendship and "Nangiles, and extends to mines which are as much as four miles in *horizontal* "distance from its mouth. Its course upwards from the adit mouth is through "the valley by Twelveheads to Hayle Mills. From this line branches go to "Wheal Friendship and Wheal Fortune.

"From Hayle Mills go two principal lines: one of them through Wheal "Virgin to West Wheal Virgin, Wheal Maid, and Carharack; from West "Wheal Virgin to the United Mines, Wheal Squire, and Ting Tang. From "the United Mines one branch goes to South Ale and Cakes, and another to "East Ale and Cakes.

"The other line from Hayle Mills goes north-west through the valley to the "eastern part of Poldice Mine, where it again divides into two principal lines. "One of these goes through Poldice Mine westward to Wheal Quick, Wheal "Jewel, Wheal Damsel, and Wheal Hope. From Wheal Jewel a branch goes "by the Great Cross-course to Tolcarne Mine, Roslabby, and Wheal Pink. "From Wheal Quick a branch goes through Wheal Gorland, and is extending "towards Wheal Clinton. From the middle of Poldice Mine a branch goes "northward through Wheal Unity to Wheal Union. From the east part of "Poldice Mine a branch goes to the east part of Wheal Unity and into "Creegbraws Mine.

"The other principal line from the eastern part of Poldice Mine, goes north-"ward through Creegbraws to Chasewater Mine, and from thence westward "through East Wheal Chance, Halbeagle, Wheal Rose, Wheal Hawke, Wheal "Messer, Wheal Peever, Good Success, and Wheal Maria. From East Wheal "Chance a branch goes to Scorrier Mine. From Halbeagle a branch to East "Downs Mine. From Wheal Hawke a branch to Briggan, and northwards "from that mine towards Wheal Barberry. From Wheal Hawke a branch to "South Wheal Hawke, Wheal Chance, Treskerby, and Wheal Boys. From "Wheal Peever a branch to Wheal Prussia, Cardrew Mine, and Wheal Derrick.

"The length of the adit, with the various branches, of which a description "has been obtained, amounts to about 26,000 fathoms, nearly 30 miles; and "the greatest length to which any branch appears to have been extended from

mark, and into which the water runs from *Cardrew Downs, North Downs, Treskerby, Wheal Chance, Chasewater Mine, Creeg-braws, Wheal Pink, Wheal Unity Wood, Wheal Unity, Poldice, Wheal Jewel, Wheal Damsel, Wheal Maid, Carharrack, Ting Tang, Wheal Squire, The United, Consolidated,* and *Union Mines,* &c.

This adit, together with its many ramifications, extends between 30 and 40 miles in length. In the more elevated parts of the district it is 60 or 70 fathoms deep; but its average depth may be from 20 to 30 fathoms; and the diminution in the expense of draining the mines, is, of course, in proportion to the depth of the adit.

The narrow valleys of the district have been all *streamed* for tin ore at various periods, and in the Carnon Valley very large quantities of it have been found.* At present it is worked beneath the sea in Restronguet-creek by means of a shaft on the mainland, and a *level* thence beneath the bed of the estuary. At high-water, vessels of considerable tonnage sail over the heads of the labourers whilst at their work.

" the adit mouth is at Cardrew Mine, which is about 4,800 fathoms, nearly 5½ " miles. The highest ground it has penetrated is at Wheal Hope, where the " adit is 70 fathoms deep at Chilcot's Shaft, and is deeper in the branches ex- " tended from thence." MR. THOMAS, *Report*, p. 28.

Mr. Wm. Phillips, Geo. Trans. o.s. III. p. 130. Mr. Burr, Mining Review, No. VI. (January, 1832) p. 207.

* " I have been told, that about 70 years back, the low lands and sands under " Perran Ar Worthall, which are covered almost every tide with the sea, have " on its going off, employed some hundreds of poor men, women and children " washing the tin ore out of them." MR. PRYCE, *Mineral. Cornub.* p. 186.

This *tin-ground* chiefly consists of very large pebbles, and reposes on the slate rock *(shelf)*; is again covered by a layer of vegetable matter mixed with a few animal remains, &c., as well as by several alternating layers of sand, shells, silt, &c.*

As the mining operations below have been so considerable, the surface of the district is covered with rubbish, and its general aspect is most barren and uninviting.† Still the almost innumerable

* Dr. Berger, Geo. Trans. o.s. I. p. 162. Mr. Smith, Ibid, IV. p. 409. Professor Sedgwick, Annals of Philosophy (1825), IX. p. 249. A Paper of my own, Cornwall Geo. Trans. IV. p. 58.

† "To one unaccustomed to a mining country, the view from Cairn Marth, "which is a rocky eminence of seven hundred and fifty-seven feet, is full of "novelty. Over a surface, neither mountainous nor flat, but diversified from "sea to sea by a constant series of low undulating hills and vales, the farmer "and the miner seem to be occupying the country in something like the confu- "sion of warfare. The situations of the Consolidated Mines, the United "Mines, the Poldice Mine, &c., &c., are marked out by spots a mile in length, "by half a mile in breadth, covered with what are termed 'the deads' of the "mine—*i. e.*, slaty poisonous rubbish, thrown up in rugged heaps, which, at a "distance, give the place the appearance of an encampment of soldiers' tents. "This lifeless mass follows the course of the main lode (which, as has been "said, generally runs east and west); and from it, in different directions, minor "branches of the same barren rubbish diverge through the fertile country, like "the streams of lava from a volcano. The miner being obliged to have a shaft "for air at every hundred yards, and the stannary laws allowing him freely to "pursue his game, his hidden path is commonly to be traced by a series of "heaps of 'deads,' which rise up among the green fields, and among the "grazing cattle, like the workings of a mole. Steam-engines, and *whims*, "(large capstans worked by two or four horses,) are scattered about; and in "the neighbourhood of the old, as well as of the new workings, are sprinkled, "one by one, a number of small whitewashed miners' cottages, which, being "neither on a road, nor near a road, wear, to the eye of the stranger, the ap- "pearance of having been dropt down *à-propos* to nothing. * * * * *

"Early in the morning the scene becomes animated. From the scattered "cottages, as far as the eye can reach, men, women, and children of all ages "begin to creep out; and it is curious to observe them all converging like bees "towards the small hole at which they are to enter their mine. On their ar- "rival, the women and children, whose duty it is to dress or clean the ore, "repair to the rough sheds under which they work, while the men, having "stripped and put on their *underground* clothes, (which are coarse flannel "dresses,) one after another descend the several shafts of the mine, by perpen-

cottages of the miners diversify and enliven its appearance, and in some spots small garden-plots have, by almost incredible labour, been cleared.*

The outskirts of the mining tract are, however, in some places well cultivated; and the thriving plantations of Scorrier, Tregullow, Trevince, and Burncoose, acquire ten-fold beauty by their contrast with the adjacent waste covered with stunted heath and "poisonous rubbish."

"dicular ladders, to their respective levels or galleries. As soon as they have "all disappeared, a most remarkable stillness prevails—scarcely a human being "is to be seen. The tall chimneys of the steam-engines emit no smoke; and "nothing is in motion but the great 'bobs' or levers of these gigantic machines.

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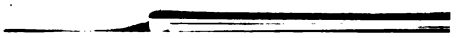
"As soon as the men come *to grass* they repair to the engine-house, where "they generally leave their *underground clothes* to dry, wash themselves in the "warm water of the engine-pool, and put on their clothes, which are always "exceedingly decent. By this time the *maidens* and little boys have also "washed their faces, and the whole party migrate across the fields in groups, and "in different directions, to their respective homes. Generally speaking, they "now look so clean and fresh, and seem so happy, that one would scarcely fancy "they had worked all day in darkness and confinement. The old men, how-"ever, tired with their work, and sick of the follies and vagaries of the outside "and the inside of this mining world, plod their way in sober silence—proba-"bly thinking of their supper. The younger men proceed talking and laughing, "and where the grass is good they will sometimes stop and wrestle. The big "boys generally advance by playing at leap-frog; little urchins run on before "to gain time to stand upon their heads; while the '*maidens*,' sometimes "pleased and sometimes offended with what happens, smile or scream as cir-"cumstances may require. As the different members of the group approach "their respective cottages, their numbers of course diminish, and the individual "who lives farthest from the mines, like the solitary survivor of a large family, "performs the last few yards of his journey by himself."

SIR F. BOND HEAD BART., *Quar. Review*, XXXVI. (June, 1827), pp. 81–82–89.

* "The quantity of inclosed ground that has been destroyed in the whole of "this district does not appear to be more than 150 acres. * * * * Thou-"sands of acres of downs, commons, and wastes have been enclosed and "improved and are continually enclosing by the miners. * * * * Two or "three thousand tons (of stone) per acre are thus removed from some spots "before the ground is cleared." MR. THOMAS, *Report*, pp. 14–15.

DRUTH AND GWENNAP. *(Pl. VII. Fig. 1.)*

Wheal Buller Cross-course.	Wh. Beauchamp Eastern Flucan.	Cross-course.	Wh. Beauchamp Western Flucan.
Cross-course divided, but not *heaved.*			
.....	This *flucan* does not reach so far S. as the *North lode.*	This *cross-course* does not continue to the *North lode.*	This *flucan* does not extend to the *North lode.*



SAINT AGNES AND PERRAN-ZABULOE DISTRICT,

bounded on the west by the parish of Illogan, e north by the Bristol Channel, on the east by ginary line drawn from the sea at Penhale to a mile inland, and on the south by another line nearly parallel to the coast.

ere is a small patch of granite at Cligger-point, he principal rock is slate, which is more or less ceous, even at considerable distances from the ite; but still further from it gradually becomes reous, until at Newquay, beyond this district, tains extensive beds of limestone, in the vicinity hich the slate rocks contain corallines, encrinites, other organic remains. *Elvan-courses* are nu- us throughout the district, and there are some em in the calcareous tracts also.

he granite of Cligger is of the ordinary kind,*

The extreme point of the headland, which is several hundred yards from ermination of the killas, very nearly resembles the common granite of ounty: but the intermediate parts, which are divided by innumerable lel fissures, exhibit such varied modes of aggregation, and are frequently ch a state of disintegration, that it is difficult to convey a correct idea of by description. They are chiefly composed of quartz, sometimes dis- ly crystallized, felspar, mica, and chlorite, in every variety of combina- and they are often porphyritic. We have remarked one unusual hyritic mass, composed of crystals of felspar imbedded in earthly ite.

ie parallel fissures are metalliferous; and the operations of mining have conducted in them to such an extent, that some parts of the rock are as as a honey-comb. These veins abound in the ores of tin, and present traces of the ores of copper. Wolfram, and some other metalliferous rals, are also very generally found in them."

PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p.p. 131-2.

t Cligga Point the felspar rocks are succeeded by a large mass of granite, is, of a crystalline rock, composed of felspar, quartz, and mica, like the ite of the central groups: it also contains large porphyritic crystals of ar, both red and white." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 303.

in some places rather inclining to coarse grained. It consists of felspar, quartz, and mica, with numerous porphyritic crystals both of pink and white felspar. Where it has been long exposed to the action of the weather the basis is decomposed, and the crystals of felspar stand out in strong relief.

The point is a bold and inaccessible cliff, but a little south of it there is a rugged and difficult path leading to the beach. The whole of this portion, and the rocks for some distance southward, are good examples of the jointed structure of granite. The principal series of joints bears about 20° S. of W., whilst a second ranges about N. and S.: but the cliff section exhibits the first to the greatest advantage. The beds of granite all dip towards the north,* are very thin, and in some parts so quartzose, and so intersected by veins of quartz, that it is not always easy to distinguish the rock and the veins from each other, especially as the whole is more or less metalliferous. The cliff is pierced everywhere and in all directions by the excavations which have been made, chiefly in search of tin; wolfram is also very abundant,† and there are traces of copper and iron pyrites.

"At Cligger Head, near the northern extremity of the district, is also a small "formation of granite occupying about ten acres of the outer part of the pro- "montory." MR. THOMAS, *Mining Review*, No. VIII. (1836) p. 265.

* "Numberless veins of granite here intersect the granite itself; the granite "in both walls of each is harder and more quartzose than the other; these "veins run very parallel, and dip all to the north; they give a stratified ap- "pearance to the rock. Quartz veins like these occur very frequently here in "the granite." M. M. VON OEYNHAUSEN AND VON DECHEN, *Phil. Mag. and Annals*, v. (1829) p. 169.

† The action of the sea saps the base of the cliff, and large portions of it fall almost every winter. These are rapidly disintegrated by the waves, and a few persons

The beds of granite are often more quartzose towards the bounding planes than they are in the centre, and they, as well as the veins, frequently intersect on the line of their dip, and produce the displacements provincially called *leaps, slides,* or *throws.*

They are all intersected by minute veins of quartz bearing N. and S., one of which I observed to *heave* the beds of granite, as well as the E. and W. quartz veins.

Southward, the constituents of the rock undergo a change, until the mica is gradually replaced by chlorite, and here the felspar is often of a brick-red colour: the joints are also less numerous, and the mining excavations in the cliff fewer.

Towards the most southern part of Hanover Cove, at Cligger south mill, another opportunity offers for reaching the sea side; here the rock assumes a coarse grained porphyritic structure, and contains a few large lumps of crystallized talc: in many places the felspar decomposes into a *china-clay.* One series of joints still continues to dip northward, but a second inclines in a contrary direction, and from their interference arises the apparently curved structure of the rock which is so very conspicuous.*

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earn a scanty livelihood by picking up the particles of tin ore from the beach; which are temporarily taken to an excavation in a large rock, surrounded by the sea at high-water. Here the labourers retire during that time of the tide; and, whilst unable to continue their pursuit on the shore, they occupy themselves in washing and *dressing* the ore which they have collected, with water drawn from the sea.

* "In one portion of the headland, the parallel beds are slightly deflected, "and soon afterwards succeeded by a mass so violently contorted, that all its "subordinate beds are convex to the horizon."

PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p. 132.

The junction of the slate with the granite is seen in many places near the point to the north, and with the porphyritic felspar rock which succeeds the granite in Hanover Cove to the south.

The succession of the beds near the northern junction is different at not very distant points.

Westward, the ascending order exposed in the cliff is as follows:—

1. Granite — — — about 60 feet.
2. Massive felspar rock, with some mica and a little quartz, 50 feet.
3. Granite, — — — 10 feet.
4. Felspar rock, like No. 2, traversed by numerous small veins of granite. 30 feet.
5. Granite, largely quarried for building, forms the highest point of the cliff.

But a short distance eastward, the cliff section exhibits, again in the order of succession:—

1. Massive felspar rock, containing mica and quartz.
2. Granite.
3. Felspar rock, like No. 1.
4. Granite; a bed or vein, — 6 feet thick.
5. Felspar slate, — — 6 feet —
6. Granite, — — — 20 feet —
7. Felspar slate, — 40 or 50 feet —
8. Granite; the quarry, No. 5, of the first section.

The line of contact between the main masses is nearly vertical, though slightly inclining towards the

west; and, horizontally, the junction bears about S.E. and N.W. There are, however, numerous indentations, and these, as exhibited in the preceding sections, are larger, more numerous, and more strongly marked than usual. Yet, on the whole, the junction at the Point seems to indicate, pretty clearly, that the granite rests in a very highly-inclined line on the slate.*

Near the Point the slate is chiefly composed of a laminated schorl-rock, consisting of felspar and schorl in alternating layers. But still further east it alternates with a greenish grey slate, the cleavage dipping south. Several *lodes*, bearing about 20° S. of W., have been worked to considerable depths.†

In Hanover Cove the junction of the slate with the porphyritic felspar-rock, into which the granite passes, to the south, is well exposed for some extent; as the angle at which the latter declines is inconsiderable. The line of junction is here very irregular, as the porphyry sometimes disappears beneath the beach, and at others rises 10 or 15 feet in the cliff, throwing off veins, bunches, and other

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* "The separation of the granite mass at Cligga Point from the killas, is "neither parallel to the fissures in the one nor to the great cleavage of the other; "but may be represented by a very irregular superficies, which is, on the whole, "nearly perpendicular to the horizon."

PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p. 132.

† "A very well characterized killas is to be seen on the eastern side of "Cligga Point; it is of a grey and greenish colour, sometimes with little red "spots like the clay slate in the neighbourhood of Viel-salm in the Ardennes. "Several tin lodes have been worked here; they run east and west, dipping to "the north, but nearly perpendicular. Wolfram is found very frequently on "the old heaps, and alittle yellow copper and tin ore." M. M. VON OEYNHAUSEN AND VON DECHEN, *Phil. Mag. and Annals*, v. (1829) p. 169.

irregular ramifications into the slate, and frequently enveloping large masses of it; whilst, on the other hand, many large lumps of the porphyry have no visible connexion with the main body, but appear to be entirely enclosed in the slate.

Near this junction the porphyry is, in general, a fine grained mixture of felspar and quartz; but occasionally it is coarse, and sometimes contains large crystals of felspar, and masses of crystallized mica, and schorl. Some of the beds are very much decomposed, but others are but little affected by *weathering*. It is traversed by several small veins of quartz, bearing about N. and S., but the joints of the rock pass through them without interruption.

The slate in the vicinity, for the most part, consists of felspar in large quantities, alternating with layers of schorl; it is very soft, sometimes contains mica, and is traversed by numerous small quartz veins; the cleavage dips towards the S.E.

A rather similar kind of slate abounds at *Wheal Music*,* in the western part of *Wheal Towan*,† at *Great Saint George*, and in *Wheal Leisure*; it has,

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* *Wheal Music* was worked on well known *lodes* for many years; at length these were split into minute strings and branches, none of which were, singly, worth pursuit. The whole rock was then removed and the copper ores extracted. An excavation of an irregular elliptical form, of about an acre in area, and twenty-five fathoms in depth, yet stands open to the day. About four millions of cubic feet of stone must have been removed. It closely resembles the net-work of tin-veins in granite, at *Carclaze*, near Saint Austell.

† "At the south end of this mine, the hill is cut down by the road-side, and "exposes two kinds of rock; the former is of a light coloured and somewhat "granular schist, the latter coarsely lamellar, harder, and apparently more "siliceous." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 293.

however, a bluish grey tinge, and is sometimes a little variegated, probably because the two differently coloured minerals are in some cases separately aggregated, and in others mixed. The joints are numerous, and the cleavage, though well marked, is irregular.

On both sides of Porth Towan is a deep blue slate, which dips S., and is much intersected by small veins of quartz. On the western side, towards the base of the cliff, it alternates with thin beds of a coarse grained arenaceous slate,* and, in several places, is incrusted with a thin calcareous stalagmite, deposited from the water percolating through it.† Southward, near *South Wheal Towan* and *United Hills*, the same slate prevails, the depth of its tints vary, it is often quartzose, and, occasionally, contains traces of chlorite; its dip is also to the south, but it is frequently contorted; the joints bear N. and S.

Following the cliff, north-eastward,‡ the same glossy blue slate prevails, through *Wheal Charlotte*, as far as Porth Chapel,—a small cove at the extremity of a long narrow gully, between very steep hills. On the N.E. side of this a greenish brown quartzose slate rises into a small but picturesque cairn: beyond,

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* Some of the spots, I suspect, may be obscure traces of organic remains.

† Whether the lime may be derived from the rock, or from the sandy soil by which it is covered, is rather difficult to say.

‡ "In the cliff a little north of Porth Towan, a curious vein of slate traverses the killas ground; this vein is bent, * * * is about ten feet wide, and fifty feet high * * *. The strata of the vein throughout are parallel to its inclination, the strata of the surrounding ground are nearly horizontal."
MR. THOMAS, *Mining Review*, No. VIII. (1836) p. 274.

in the direction of *Wheal Coates*, the cliff is approached with difficulty, on account of the steep slope of the hill, and the road has been cut, for several feet deep, through a dark brown decomposed slate, still, probably, *in sitû*, as its fragments have a regular position, and incline to the south. A similar rock appears for some extent in the cliff at *Wheal Coates*, and a large *lode*, bearing about E. and W., dipping S., and principally composed of oxide of iron and ferruginous quartz, has here been worked. An *elvan-course*, having the same direction and dip, lies on the *lode*: it is about 8 or 10 feet wide, and is composed of felspar and quartz.

As the coast trends to the northward this is succeeded by a reddish brown and somewhat variegated slate, very coarse grained and apparently decomposed, which extends far up the side of Saint Agnes Beacon Hill, and, in some places, alternates with a blackish brown compact rock. At *Wheal Coates* there is a very large mass of a coarse grained granitic rock, containing many porphyritic crystals of felspar; its relations are obscure, and I am unacquainted with its extent.* In some places it is very schorlaceous, and in others it abounds in decomposed felspar, producing a *china-clay* of inferior quality.

* "On the west side of the beacon occurs a quartzose rock like that near "Cligga Point; frequent pyramids of quartz cover the surface; clay is raised "from a great many shallow pits; certainly the granite may not be far below "this place." M. M. VON OEYNHAUSEN AND VON DECHEN, *Phil. Mag. and Annals*, v. (1829) p. 170.

"The beds of growan underlie a little to the north, and several parallel lodes, "which are for the most part very small, run through them * * * *. But

The slate, which is usually reddish brown, here and there becomes brick red, and is often micaceous. It extends round the point of Cairn Gowla, (where it is intersected by an *elvan-course*)* almost to *Polberrow*, and, on the side of the Beacon Hill, it reaches northward as far as *Wheal Pye*. It, everywhere, dips towards the south, and its joints bear, respectively, about N.E. and S.W., and S.E. and N.W.

A pale blue slate, of a silky lustre, appears at *Polberrow*, (where an *elvan course* is visible) and is traversed by numerous small tin veins.† The same rock extends to Trevaunance, forming the cliffs between that place and Trevellas Coombe, and contains many small veins of quartz: several *lodes* and

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"what is most remarkable, a great portion of this rock consists of alternate "courses of hard and soft growan running in an east and west direction, * * "* * * * * and extends to a breadth of 250 fathoms. This (soft) rock has "been sunk through to the depth of 60 fathoms * * * *. The extent of the "soft growan eastward, * * * * towards the foot of the beacon, is about "350 fathoms." MR. HAWKINS, *Cornwall Geo. Trans.* IV. p.p. 141-2.

"At the foot of the beacon is Wheal Coates tin-mine, situated in an *elvan*, a "felspar porphyry, the base of which is granular: some parts of it contain "large crystals of felspar, and coarse transparent grains of quartz, with a few "minute scales of mica; and others resemble granite: as is of very common "occurrence in the centre of extensive beds of felspar-porphyries. The two "kinds are said to alternate; the former is softer than the latter, on account of "its being extensively decomposed, forming on a small scale a bed of china-"clay, which is of bad quality, being more or less stained by metallic sub-"stances: it is employed as a *coating* for the bottom of furnaces. This *elvan* "is of considerable extent." DR. BOASE, *Cornwall Geo. Trans.* IV. p.p. 294–5.

* Southward of that which is seen *in sitû* I observed many large scattered blocks of fine grained schorl and quartz; but I could not discover whether they have been transported from *Wheal Coates*, or form part of another *elvan* in the cliff.

† In pursuit of these little tin veins the excavations have been so numerous and extensive, that a mass of rock, extending from the surface to 60 fathoms deep, being unsupported, is now (1838) slowly subsiding. The portion thus in motion is, perhaps, 60 or 80 fathoms in diameter, and its descent, at the rate of 6 or 8 feet in a month. The miners still continue their labours in the moving mass.

cross-courses also intersect it. The cleavage still inclines to the south.

A similar rock continues all the way to Hanover Cove, with little variation; except that, in some places, it is whiter, and, in others, bright red, from decomposition.

The action of the waves has deeply indented the coast, the sea is rapidly making inroads on the land, and the beach is, in many parts, covered with *debris*.

In several small headlands, thus produced, an *elvan-course*, of from 6 to 8 fathoms wide, dips to the north.

Eastward of Cligger Head, and nearly as far as Vugh-an-flaunder, a mottled quartzose slaty rock prevails near the coast; it generally dips to the south, but is much curved, and often disposed in alternating laminæ of black and white. Inland a pale grey and soft slate occurs; and this, passing from a pale buff into a light blue, continues to Perran Porth, where it forms the cliffs on both sides, rising through the sand in several places, and composing the promontory of Penhale, and Carter's gull-rock. The joints, respectively, bear about 20° S. of W. and 20° W. of N.; and the cleavage dips towards the south-west.

Near the granite the general character of the slate is a massive felspar, with some schorl and quartz: at a distance it is of a coarse grained brownish red, passing into a pale blue, with a silky lustre. The prevailing dip is to the south, and the general directions of the joints the same as before.

At *Wheal Basset* there is an *elvan-course* of considerable breadth, which bears several degrees S. of W.

Another, already mentioned, occurs in the cliff at *Wheal Coates*, and is probably connected with the extensive mass of granitic porphyry in the same mine. It is only from 8 to 10 feet wide, and is the smallest as well as the only one in the district with a southerly inclination.

The next *elvan-course* strikes into the sea at Cairn Gowla, is seen also in the adits of *Wheal Devonshire* and *Seal Hole*, and again, in the cliff at Pell-leat. An easterly extension of the same *course* falls on the headlands east of Trevellas Coombe, and, if prolonged still further in the same direction, it would reach to *Wheal Prudence*,* where, I suppose, it is the *south elvan*.† Its direction is about 25° S. of W., and its dip 30–50° N.; its thickness varies from 5 to 8 fathoms, and its junction with the slate is, in every case, clear and distinct. At *Seal Hole* adit there is something like a transition between the north *wall* of the *elvan* and the slate, both rocks becoming finer grained and more quartzose near the line of contact, but that is, nevertheless, well marked. At Pell-leat, for about a foot thick on the northern part of the *elvan*, the joints are very open, although

* It is very accurately laid down by Mr. Thomas in his Maps of the Carn Menelis district, which are deposited in the Museum of the Royal Institution of Cornwall.

† The northern *elvan* in *Wheal Prudence* is within 30 fathoms of the southern one; if, therefore, the former were the one in question, I think the latter must have become visible, either in the cliffs, in Trevellas Coombe, in Trevaunance Porth, or in some of the mines near the Beacon Hill.

the rock is not decomposed; in several parts of it irregular masses of tin ore have been found, and some workings have been commenced. In the headlands, east of Trevellas Coombe, the *elvan* varies in size very greatly, and throws off many veins, strings, and branches, into the slate, and, in one spot, encloses a very large mass of that rock.* Wherever its *back* comes to the surface in these promontories, the rock is fine grained, much decomposed, and consists, almost entirely, of felspar.

The manner in which this *elvan-course* is affected by the *lodes* and *cross-courses* is most instructive. In all the points of land which it traverses, it is itself intersected by *lodes* which have a similar direction, but an opposite dip, and *throw* it upward. One of them† raises it about 6 or 8 fathoms in each of the three eastern headlands.‡

The same *elvan* is *heaved* a fathom to the right, (G. A.) by *Seal Hole cross-course;* about 10 fathoms, in a similar direction, by a large *cross-course* between the third and fourth promontories in Trevellas Downs; and about 5 fathoms, in a like manner, by the *cross-course* at *Wheal Prudence.*

These disturbances of an *elvan*, I believe, are not parallelled in any other case, yet discovered, in this county.

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* Mr. Conybeare's Sketch, Geo. Trans. IV. Pl. XXIII. fig. 3, does not sufficiently indicate this circumstance.

† Probably, the *Polberrow Gossan lode.*

‡ This is neither figured nor described in Mr. Conybeare's account of this *elvan*, Geo. Trans. IV. p. 401, and Pl. XXIII, fig. 2–3.

The northern *elvan*, at *Wheal Prudence*, appears on the face of the cliff, and again, in a small rocky hummock, between that mine and Wheal Cock cove; in the latter place, where it is largely worked for the manufacture of troughs, &c., and for building materials, it bears about 25° S. of W., dips N., and is 11 fathoms wide. This is also *heaved* by *Wheal Prudence cross-course* about 5 fathoms to the right.

I am uncertain as to the identity of these *elvans* at any other point: whether they unite in either direction is difficult, if not impossible, to say, but in neither are two *elvans* observed near each other.

A similar rock occurs at Ponsmere, in Perran Porth, is quarried a little eastward of that place, and again appears in *Wheal Budnick*.

A small mass of *elvan* rises through the sand near the middle of the shore of Ligger-bay, but its size, dip, and direction, cannot be ascertained.

An *elvan*, about 6 fathoms wide, bearing N.W., and dipping 50–70° S.W., occurs in the eastern corner of that Bay, in contact with a large iron vein.

Two interesting *elvans*, one 6 and the other 12 feet wide, both bearing about 20° S. of W., and dipping N., appear at Penhale. The larger of them is seen in three places in the deeply indented cliffs, where it throws off numerous shoots and veins into the slate, and also encloses several patches of it. *Penhale lode* bears 20° W. of N., dips E., and *heaves* this *elvan* some fathoms to the left.*

* The exact distance I could not measure, as it was covered by the sea; through which, however, the *elvan* and *cross-course* were clearly discernible.

The general bearing of the *lodes* is between W. and S.W., their dips are various, and the results of their interferences on the lines of their inclinations are usually attended by the displacements already mentioned, as *leaps*, *slides*, or *throws*,* which have long rendered this district remarkable.†

The tract near the Beacon Hill had long been known as very productive of tin ore,‡ but, except at *Polberrow*, *Wheal Coates*,§ and *Seal Hole*, there is now comparatively little obtained from the mines which were formerly so valuable. *Blue Hills*, *Goon Lax*, and *Wheal Pink* are abandoned; and the most profitable tin mines in the neighbourhood are *Wheal Kitty* and *Wheal Budnick*, which are recent discoveries. Most of the mines have yielded finely crystallized specimens of the oxide of tin.

Both the eastern and the western parts of this district have produced large quantities of copper ore, generally in the state of pyrites, as at *Wheal Towan*, *South Wheal Towan*, *United Hills*, *Wheal Music*, *Wheal Basset*, *Wheal Charlotte*, *Wheal Prudence*, *Great Saint George*, *and Wheal Leisure*, and some of them have also afforded fine specimens

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* See *Polberrow*, Table LXXVII, Pl. IX. fig. 1-2. In this mine the tin veins are frequently *thrown* down by certain laminæ of the slate, which coincide with the dip of the cleavage planes.

† Mr. Pryce, Mineralogia Cornubiensis, p. 107, Pl. I. fig. 1. Mr. William Phillips, Geo. Trans. II. p. 137, Pl. VII. fig. 7. Mr. Carne, Cornwall Geo. Trans. II. p.p. 87-90-91, Pl. II. fig. 1-4-5-6.

‡ Tin pyrites, which is nowhere abundant, has been found chiefly at *Wheal Rock*, in this district.

§ The siliciferous oxide of tin, in pseudomorphous crystals, has been obtained in this mine. Mr. Stephen Davey, Cornwall Geo. Trans. IV. p. 484.

of native copper, some
lized oxide of copper, vi
of the rare salts of the
several of the mines.

There are several very large *cross-courses* in this district. The *great cross-course** is said to strike the north coast a little
of Porth Towan, and to continue through *Cliff*
it is observed nowhere else in the neig

In *Seal Hole* there
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Another vein, of th
Downs, *heaves* the *elvan*
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At *Wheal Prudence*,
cross-course heaves both the *lodes* and the
towards the right, but not always an equal distance.

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* "The most considerable of these cross courses extends from sea to sea; it "passes directly through the meridian of St. Agnes, leaves in the middle of its "course the parish of Stythians, three-quarters of a mile to the west, and termi- "nates on the south in the neighbourhood of Pedn-Boar-Point."

DR. BERGER, *Geo. Trans.* I. p. 165.

"This vein is believed to run quite across the country from sea to sea."

MR. WILLIAM PHILLIPS, *Geo. Trans.* II. p. 156.

"The principal cross courses in Cornwall have been traced from the shore of "the Bristol Channel, near Porth Towan, through St. Agnes, and Illogan "Parishes, to Huel Peever. In the cliff they are at some distance from each "other." MR. CARNE, *Cornwall Geo. Trans.* II. p. 108.

"The "great cross course," as it is called, both from its extent and the mag- "nitude of the heaves which it occasions, has been traced across the county, "from the north coast to the south."

MR. BURR, *Mining Review*, No. VI. (1832) p. 223.

The Porth Towan vale is a little east of the *cross-course*, and is nearly parallel to it.

Two *cross-courses* occur in Ligger-bay, a little eastward of Perran Porth; one is about a foot wide, and the other 3 or 4 fathoms; both contain crystallized quartz, and, the larger, also earthy brown iron ore, and ferruginous quartz; both bear about N. and S., and dip E. 60–70°. I do not know their effects on the *lodes*, but I may state that on the western side of the larger the slate is blue and very quartzose, whilst, on the east, it is pale grey, and, in some places, tinged deep red by decomposition.

At the eastern extremity of Ligger-bay, and in contact with the *elvan* already mentioned, is a large vein, bearing about S.E. and N.W., and dipping S.W. 50°. It contains hematite, specular, and earthy brown iron ore, quartz, and slate: has many cavities lined with crystals of quartz, and is traversed by many small quartz veins.

The vein on which *Penhale* and *Wheal Golden* were worked for galena, bears 25° W. of N., dips E. 70–80°, and re-appears in three or four of the small headlands. Its contents are mostly quartz and galena; and, in several places, there are spheroidal masses of crystallized quartz imbedded in the ordinary variety of the same substance.

Further eastward there are other veins which have produced galena in large quantities: some of them bear E. and W., others N. and S., and a few in intermediate directions,* but at present they are but little worked.

* "The lead veins which have been lately discovered in the parish of "Newlyn, by Sir Christopher Hawkins in draining a marsh, * * are about

The first discovery of silver in Cornwall is said to have been made at *Wheal Mexico*, in this district.*

At *Wheal Towan*, and in the western part of the district generally, the *shoots* of ore dip westward; but, on the east of Cligger, the *bunches* have an opposite inclination.

As in most other places, there is an approximate coincidence between the directions of the joints and of the principal veins in their neighbourhood.

At Porth Towan, one system of joints bears between N. and S., and a second, a few degrees S. of W.: similar directions prevail as far as *Wheal Charlotte*. Near *Wheal Coates* the principal of them are about N. and S., and another set, about 20° N. of W., and these bearings continue to Cairn Gowla. At the latter spot, and at Pell-leat, the joints, in some instances, pass through both slate and *elvan* without interruption; some again seem to traverse the slate alone, and others are confined to the *elvan*.

The E. and W. joints prevail at Trevaunance Cove, Trevellas Coombe, and along the cliff to *Wheal Prudence*, and those which divide the

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" two feet wide, and run nearly east and west: a direction contrary to that of " almost all the other lead veins which have been hitherto discovered in Corn- " wall. Besides the lead, and a little quartz, they consist entirely of clay. " * * * The lead yields about 60 ounces of silver per ton."

MR. CARNE, *Cornwall Geo. Trans.* II. p. 114.

* " The vein which was formerly worked at Huel Mexico in Cornwall, was " in grauwacke slate. The ore appeared to be mixed in it in the form of " insulated masses or nests; besides the native silver, corneous ore (muriate " of silver) was also met with." DR. BERGER, *Geo. Trans.* I. p. 171.

Mr. Carne, Cornwall Geo. Trans. I. p. 121.

granite at Cligger Point have commonly the same direction, although many of them bear N. and S. The latter are also general between Cligger and Perran Porth, and they are also the principal in the eastern part of the district, where they seem to traverse, equally, both rocks and veins.

The valley of Porth Towan has been *streamed* for tin, but with little success.*

The beds of sand and clay on the eastern, northern, and western sides of the Beacon Hill, are among the most curious formations in the county.† They are

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* "Stream tin has been met with * * * at Perran Porth in the parish of "Perran-zabuloe, below the sea-sand in the form of large blackish grains."
DR. BERGER, *Geo. Trans.* I. p. 162.
I have seen specimens of wood-tin from one of the *lodes* in *Polberrow*.

† "The deposit of sand, clay, and alluvial fragments of rock, occurs at an "elevation of 375 feet above high water. * * * The greatest breadth of this "deposit, which amounts to 150 fathoms, is on the eastern side of the beacon. "It gradually contracts on the northern to 70 fathoms, and vanishes about half "way in its progress along the western side. * * * * Close by a mine which "is called Wheal Gobe beneath the vegetable mould I found a deep bed "* * * not materially differing from what usually covers the killas rock. "This was succeeded by fine clay in a bed of two feet, then by clay and sand "to the farther depth of three feet, and ultimately by a fine white grit sand, the "depth of which has not been ascertained. On the edge or margin of this "deposit, where it joins the base of the beacon, the beds of sand and clay are "said to disappear rather suddenly, and the rubble alone remains. Here at a "spot called Opie's field, where the rubble is, for the most part, 20 feet deep, "has been found, immediately beneath it and on the surface of the bare rock, "no small quantity of alluvial tin, in fragments of all sizes. * * * * * * * "On the north side of the beacon I found the yellow cobb, two feet and a half "in depth mixed with a great proportion of rubble. * * * The next to it, in "succession, was a bed of brown sand, which attained a thickness of nine feet. "This bed also underlies to the north, but has numerous sedimentary divisions "which dip at an angle of 45° to the south. Then occurred nine or ten feet of "bluish gray, and brown clay, some portions of which had a slight admixture "of carbonic matter. This bed is capped with four or five inches of white "clay, * * * what lies deeper is mixed with * * * sand. Below this "sandy clay they find fine grit six or seven feet deep, until they reach the rock."
MR. HAWKINS, *Cornwall Geo. Trans.* IV. p.p. 136-8.
"The stratum of blue clay is about a foot in thickness. It is very tough and

often covered by a bed of loose stones and earth, which is sometimes as much as 6 or 8 feet thick. Beneath this is a bed of pink, yellowish, or, in some places, brownish sand, varying from 2 to 10 feet in depth, divided into separate layers which incline towards the south, and, in various parts, contain small ferruginous crusts and masses of conglomerate, and sometimes the lower portions are mixed with a little clay. A bed of stiff blue clay,* of a foot or a foot and a half in thickness, succeeds; and again below this is a bed of milk-white sand, the upper part of which is occasionally mixed with small portions of clay. Beneath the whole, and lying on the rock, there is often a bed of pebbles, in which a little *stream-tin* is said to occur occasionally.

It is not a little remarkable that at distant spots the elevation of the same bed is frequently different.†

" adhesive, and so firm that when dry it is cut with a broad chissel into square " lumps; when dry it is of a light chocolate colour mottled with irregular " black markings; it has an oily rancid smell, like putty, which is not increased " by being breathed on, nor does it emit an argillaceous odour; it is soft and " greasy to the touch, and readily takes a polish; it imbibes moisture greedily, " adhering strongly to the tongue; and when thrown into water it swells and " falls into a soft paste; when calcined it becomes light coloured, and loses its " rancid odour. The peculiar properties of this clay appear to be derived from " a strong impregnation of animal matter."

DR. BOASE, *Cornwall Geo. Trans.* IV. p. 297.

* The clay is moistened and applied to the miner's candle, in order to prevent the warmth of the holder's hand from injuring it, and in order to attach it to the rock, in a convenient spot for the workman whilst at his labour. It is sold in the place at the rate of twenty shillings per ton, and is conveyed to very distant parts of the county for use in the mines.

† Mr. Thomas has kindly favoured me with the following valuable observations on the elevations of the beds at various parts of the Beacon, obtained by his own levelling from the high-water mark.

" North-eastward of the beacon, about half a mile, there are sand pits, and " the ground 383 feet above high-water. The sand is yellow, and is 8 feet un- " der the surface, covered with a bed of clay 2 feet thick.

" Northward from the beacon half a mile, and near Wheal Kind sand pits,

There are considerable accumulations of sea sand on the eastern sides* of Porth Towan and Perran Porth, but that at the latter place is by far the most extensive. In both, partial agglutinations of the sand have formed masses of stone; but, I believe, few of them have been employed for building. The encroachments of the sand during heavy storms have been most destructive to the land in the immediate vicinity:† large tracts have been irrecoverably lost, and two churches have been successively abandoned in consequence of its advance into the interior.

" the ground is 383 feet above high-water: the sand is 7 feet under the surface, " and the pit goes 8 feet through white sand.

" About half a mile north-westward of the beacon, the ground near the sand " pit is 377 feet above high-water, the sand is 3 feet beneath the surface, and " the pits are 15 feet through yellow sand.

" About a quarter of a mile south-westward of the beacon, the surface is " 418 feet above high-water, the sand is 9 feet beneath, the pits are sunk 12 feet " through yellow sand: the portions which are deepest in the bed have the " lightest tints.

" The top of the beacon is 612 feet above high-water."

It will be readily admitted that these results are more worthy of credit than Dr. Berger's, which were obtained by the use of a mountain barometer; or those in the Ordnance Survey, which are derived from comparison with very distant stations. The first states the elevation of the Beacon at 664, the latter at 599 feet.

" Saint Agnes, one of the high hils, by his entrailes (like *Prometheus*) feed- " eth the Tynners' pecking, or picking bils, with a long liued profit, albeit, their " scarcle Eagle eyes sometimes mistake the shadow for the substance, and so " offer vp degenerate teares, as a late sacrifice to repentance."

MR. CAREW'S " *Survey*," p. 148.

* " The vast and apparently constant accumulation of this sand in all the " places where projecting headlands form bays or gulphs facing to the west, and " consequently open to the direct roll of the Atlantic Ocean, occasions, in such " positions all along the coast, the formation of those towans or sand-hills which " cover some thousands of acres of ground, and furnish an inexhaustible store " of calcareous manure. * * * Where in such situations the cliffs are low, the " sands have covered them, having first, by their accumulation, formed a slope " of easy ascent, over which succeeding sands have been wafted, and have ex- " tended inland." MR. THOMAS, *Mining Review*, No. VIII. (1836) p. 272.

† My father has informed me that, within seventy or eighty years, a field in preparation for tillage by some of his relatives in this neighbourhood, was,

The sea-reed (*arundo arenaria*) has been extensively planted, and, by protecting the sand from the action of the wind, has prevented a recurrence of such wide-spread devastations as are recorded to have formerly taken place.

In the vicinity of the veins the rocks are often softer than they are elsewhere: in such places the erosive action of the waves has worked numerous caverns in the cliffs.* Some of these are very extensive, as at Vugh-an-flaunder, *Wheal Prudence, Seal Hole,* and *Wheal Devonshire:*† the former may be entered from the beach, when the tide is very low, and is frequently visited and illuminated; the others may be approached inland, through the adits which open into them, or in boats, when the weather is very calm and the sea smooth.

A great part of this district, without cultivation or enclosure, is most wild and desolate. But the sea-coast, with its pleasant coves and level sandy beaches, is much resorted to by those to whom it would be inconvenient to take a distant journey to more fashionable, though not more healthful, watering places; whilst its lofty and caverned cliffs, whose decomposing rocks assume an endless variety of

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during a storm, irreclaimably covered in a single night by sand, which was drifted to the depth of a foot.

It is said that barley grown on these sandy soils is generally heavier and of better quality than elsewhere.

* "I have seen no part of the sea-coast of Cornwall where the destructive "influence of the waves is so well illustrated.

DR. BOASE, *Cornwall Geo. Trans.* IV. p. 302.

† In this cavern I suffered a fracture of my right arm.

tints,* attract many summer pleasure parties and lovers of romantic scenery.

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* "The upper part of the rocks is seen to be in a state of decomposition, as "shewn by their bright red colour."

DR. BOASE, *Cornwall Geo. Trans.* IV. p. 300.

Name and Dtn. of vein.	Depth, fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
North Lode, 25° S. of W.	10.	N. 32–41°	4 to 7 feet.	Quartz, quartzose slate, iron and copper pyrites.....	*Slate*, deep greyish blue, thick lamellar; dip of cleavage S.W. 12°.
	—	N. 48–58°	2 to 4 feet.	W. Granular quartz, earthy brown iron ore, copper pyrites, black copper ore, and slaty clay.	Idem, passing into yellowish grey; dip S.W. 12–16°.
	20.	N. 35–40°	7 to 10 feet.	Quartz, and dark slaty clay, traversed by numerous minute veins of copper and iron pyrites.	Pale greyish, thick lamellar; dip S. 10°, and S.W, 15°.
	—	N. 56–64°	2 to 4 feet.	W. Quartz, quartzose slate, iron and copper pyrites, and numerous *vughs* lined with crystallized quartz. There are traces of horizontal *bedding* in the *lode*, and the joints are filled with felspar clay.	
	27.	N. 38–50°	4 to 7 feet.	Quartz, quartzose slate, copper and iron pyrites; a vein of felspar and granular quartz, 6 inches wide, occurs in the *lode*.	Deep greyish blue, with rather imperfect cleavage: dip S.W. 10–15°.
	—	N. 58–70°	3 to 4.5 ft.	W. Decomposed slate, iron pyrites, quartz, and spots of black copper ore.	
	40.	N. 30–38°	5 to 7 feet.	Quartz, quartzose slate, copper and iron pyrites.	Idem.
Stacey's Lode, 25° S. of W.	27.	N. 56–60°	2 to 3 feet.	Copper and a little iron pyrites, quartz, and deep blue slaty clay,	Pale grey, traversed by numerous small veins of iron and copper pyrites, towards the *North lode*.
	40.	N. 60–65°	3 to 4.5 ft.	Quartz, slaty clay, copper and iron pyrites.	

UNITED HILLS MINE, PARISH OF SAINT AGNES.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
LODE, 26° S. of W.	42.	N. 38–45°	4 to 7 feet.	Quartz, quartzose slate, copper and iron pyrites.	*Slate*, deep blue, silky lustre, thick lamellar; dip of cleavage S.W. 12°.
	—	N. 30–40°	4 in. to 7 feet.	Slaty clay, quartzose slate, enclosing irregular masses of slate, which sometimes shade off into the quartz, and at others the junctions are sharply defined.	Pale greyish blue, the laminæ of very different colours, and sometimes much curved; dip S.W. 18°.
	52.	N. 30–48°	4 to 8 feet.	Quartz, quartzose slate, copper and iron pyrites.	

Table LXXI.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Slide Lode.
SLIDE LODE, N.E. & S.W.	20.	N. 58–66°	0.6 to 1 foot.	Earthy brown iron ore, quartz, and slaty clay, with mineral pitch in the *vughs*.	*Slate*, pale buff, passing into pale blue, thick lamellar; dip S.W. 10–12°: joints N. and S.	
	30.	N. 60–68°	1.5 to 2 feet.	Slaty clay, earthy brown iron ore, copper and iron pyrites,—often in two *veins*.	Idem.	
	36.	N. 55–64°	2.5 to 3.5 ft.	Quartzose slate, earthy brown iron ore, quartz, and copper pyrites,—the *vughs* often full of mineral pitch.	Deep blue, thick lamellar; dip S.W. 16–18°.	
SOUTH LODE, 24° S. of W.	20.	S. 60°	2 to 3 feet.	*Walls* smooth; quartz, earthy brown iron ore, spots of copper pyrites, and mineral pitch.	Pale buff; dip S.W. 12–16°.	
	30.	S. 65-72°	2.5 to 3.5 ft.	Quartz, earthy brown iron ore, slate, and copper pyrites.	Idem.....	*South lode thrown* up 25 fms. S.A. At 10 fms. up, the *Slide lode* is in two veins, and a portion of the S. *lode* is included between them.
	36.	S. 68–74°	4.5 ft.	Quartz, quartzose slate, chlorite, and copper pyrites; the latter chiefly on the S. *wall*.	Pale bluish green; dip S. 16°.	
CROSS-COURSE N. and S.	20.	E. 80–84°	0.6 to 1 foot.	Quartz, slate, and felspar.....	.....	*Lode heaved*, 2 feet L.G.A.

SOUTH WHEAL TOWAN, PARISH OF SAINT AGNES. *(Pl. VII. Fig. 15–15a.)*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Slide Lode.
Slide Lode, N.E. & S.W.	20.	N. 58–66°	0.6 to 1 foot.	Earthy brown iron ore, quartz, and slaty clay, with mineral pitch in the *vughs*.	*Slate*, pale buff, passing into pale blue, thick lamellar; dip S.W. 10–12°: joints N. and S.	
	30.	N. 60–68°	1.5 to 2 feet.	Slaty clay, earthy brown iron ore, copper and iron pyrites,—often in two *veins*.	Idem.	
	36.	N. 55-64°	2.5 to 3.5 ft.	Quartzose slate, earthy brown iron ore, quartz, and copper pyrites,—the *vughs* often full of mineral pitch.	Deep blue, thick lamellar; dip S.W. 16–18°.	
South Lode, 24° S. of W.	20.	S. 60°	2 to 3 feet.	*Walls* smooth; quartz, earthy brown iron ore, spots of copper pyrites, and mineral pitch.	Pale buff; dip S.W. 12–16°.	
	30.	S. 65-72°	2.5 to 3.5 ft.	Quartz, earthy brown iron ore, slate, and copper pyrites.	Idem.....	*South lode thrown* up 25 fms. S.A. At 10 fms. up, the *Slide lode* is in two veins, and a portion of the S. *lode* is included between them.
	36.	S. 68–74°	4.5 ft.	Quartz, quartzose slate, chlorite, and copper pyrites; the latter chiefly on the S. *wall*.	Pale bluish green; dip S. 16°.	
Cross-course N. and S.	20.	E. 80–84°	0.6 to 1 foot.	Quartz, slate, and felspar.....	.....	*Lode heaved*, 2 feet L.G.A.

Table LXXII.

SOUTH WHEAL TOWAN, PARISH OF SAINT AGNES. *(Pl. VII. Fig. 15–15a.)*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Slide Lode.
Slide Lode, N.E. & S.W.	20.	N. 58–66°	0.6 to 1 foot.	Earthy brown iron ore, quartz, and slaty clay, with mineral pitch in the *vughs*.	*Slate*, pale buff, passing into pale blue, thick lamellar; dip S.W. 10–12°: joints N. and S.	
	30.	N. 60–68°	1.5 to 2 feet.	Slaty clay, earthy brown iron ore, copper and iron pyrites,—often in two *veins*.	Idem.	
	36.	N. 55-64°	2.5 to 3.5 ft.	Quartzose slate, earthy brown iron ore, quartz, and copper pyrites,—the *vughs* often full of mineral pitch.	Deep blue, thick lamellar; dip S.W. 16–18°.	
South Lode, 24° S. of W.	20.	S. 60°	2 to 3 feet.	*Walls* smooth; quartz, earthy brown iron ore, spots of copper pyrites, and mineral pitch.	Pale buff; dip S.W. 12–16°.	
	30.	S. 65-72°	2.5 to 3.5 ft.	Quartz, earthy brown iron ore, slate, and copper pyrites.	Idem.....	*South lode thrown* up 25 fms. S.A. At 10 fms. up, the *Slide lode* is in two veins, and a portion of the S. *lode* is included between them.
	36.	S. 68–74°	4.5 ft.	Quartz, quartzose slate, chlorite, and copper pyrites; the latter chiefly on the S. *wall*.	Pale bluish green; dip S. 16°.	
Cross-course N. and S.	20.	E. 80–84°	0.6 to 1 foot.	Quartz, slate, and felspar.....	.....	*Lode heaved*, 2 feet L.G.A.

Table LXXII.

EAST WHEAL CHARLOTTE, PARISH OF SAINT AGNES.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Lode.
LODE, 13° S. of W.	14.	S. 60–64°	10 to 12 inches.	Quartz, some of it granular, iron pyrites, and black copper ore.	White slaty matter, with no distinct dip, traversed by minute veins of quartz, iron and copper pyrites, and black copper ore.	
	24.	S. 50–70°	2 feet	Quartz, and slaty matter.....	Slate, hard, blue, silky lustre; dip S. 10–12°.	
	—	S. 60–64°	3 to 4 feet.	W. Quartz, iron pyrites, and black copper ore.	Decomposed, white clay, with irregular masses and strings of quartz.	
					Greyish white numerous joints, with strings of quartz,—apparently composed of felspar and quartz.	
	42.	—	—	.....	Thick lamellar, greyish white; dip S.W. 32°, with many minute quartz veins.	
	—	—	—	.....	Decomposed greyish-white felspar, and quartz; dip S.W. 14°. A vein of slaty clay, dip S. 60°, 2 inches big, appears to *heave* the joints of the rock.	
CROSS VEIN, 20°W. of N.	24.	E. 80–82°	1 to 4 inches.	White felspathic slaty clay.....	....	*Lode* intersected, but not *heaved*.

Table LXXIV.

WHEAL DEVONSHIRE, PARISH OF SAINT AGNES.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Lode.
CAND LODE, 24° S. of W.	50.	N. 68–76°	1.5 to 2 feet.	Fluor, in extremely small and unconnected masses, apparently disintegrated, without any regularity of form.	*Slate*, deep blue, silky lustre; in some places very micaceous; dip S.W. 20°.	
CROSS-COURSE 20° W. of N.	50.	W. 70–84°	1.5 to 2.5 ft.	In slate. Quartz, and slaty clay.....	In some places coarse granular micaceous felspar slate.	*Lode* intersected, but not *heaved*.
	—	—	—	In *elvan*. Irregular masses of *elvan*, and quartz.	An *elvan-course* of an extremely fine grained basis of felspar, and quartz, with a few small porphyritic crystals of felspar. It is 3 to 5 fathoms wide; bears S.W.	

Table LXXV.

PENWINNICK MINE, PARISH OF SAINT AGNES.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Lode.
LODE, 40° S. of W.	22.	S. 62-82°	1 inch to 3.5 ft.	*Slate*, crystalline quartz, iron and copper pyrites:—here and there a few spheroidal masses of slate are imbedded in the *lode*.	Slate, deep blue, silky lustre; dip of cleavage S.W. 12°.	
	32.	S. 68-82°	a line to 4 ft.	Quartz, with the same globular lumps of slate, copper and iron pyrites.	Idem; S.W. 12-20°.	
	42.	S. 68-70°	3 feet.	Quartz, slate, and iron and copper pyrites.	Idem; S.W. 40-42°.	
SLIDE, N.E. & S.W.	22.	S.E. 42-50°	4 in.	Slaty clay, and granular quartz.....	.....	The *slide traverses* the lode but does not *heave* or *throw* it; but for 10 fms. horizontally the *lode* is deflected, and follows the direction of the *slide*.
	32.	S.E 40-50°	—	Idem.		

Table LXXVI.

INT AGNES. (*Pl. IX. Fig. 1–2.*)

ock.	South House Lode.	Great Gossan Lode.	Western Cross-course.	Eastern Cross-course.
istre, thick vage S. to to the *lode*, '.	*Pye Lode thrown* up 3 fms. S.A.	.....	.....	*Lode heaved* 9 feet R.G.A.
.....	.....	.....	.....	*Lode heaved* 12 feet R.G.A.†
.....	.....	.....	.....	*Lode heaved* 12 feet R.G.A.‡
.....	*Trevaunance Lode thrown* up 2 fms. S.A.	*Trevaunance Lode thrown* up 2.5 fms. S.A.		
any of the which are inch to a f the slate, stinguish- t by being	.....	.....	*Branches heaved* 6 in. L.G.A.	
1–18°....	.....	.....	.....	*Lode heaved* 9 feet R.G.A.

WEST PINK MINE, — (Pl. IX. Fig. 3-4.)

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Carrow Gossan Lode.	Great Gossan Lode.	Tin Lode.
Tin Lode, (in *Friendly* Mine) 25° S. of W.	60.	N. 40-46°	3 to 4 feet.	Quartz, quartzose slate, copper pyrites, and a very little oxide of tin.	*Slate*, deep blue, silky lustre, curved, and quartzose: joints parallel to the *lode*.			
	70.	N. 48-52°	1.5 to 2 feet.	Quartzose slate, quartz, oxide of tin, iron and a little copper pyrites.	Idem	.....	Between *Friendly* and *Primrose*, the *Gossan lode throws* up the *Tin lode* 40 fms S.A.(*b*)	
(in *Primrose* Mine)	59.	N. 28-36°	—	Quartz, quartzose slate, and a very little oxide of tin.	Deep blue; dip of cleavage S. 12°.			
	66.	N. 22-28°	4 to 5 feet.	Oxide of tin, fluor, and a little copper pyrites, in quartzose slate.	Idem	*Tin lode thrown* up 7 fms. S.A.(*a*)		
Carrow Gossan Lode, (in *Primrose* Mine) 22° S. of W.	25.	S. 76°	1.5 to 2 feet.	Quartz, and earthy brown iron ore.	Idem.			
	66.	S. 62-70°	1 to 1.5 foot.	Quartzose slate, iron and copper pyrites. *Vughs*, lined with crystals of quartz, and copper pyrites.	.....	.....	.....	(*a*)
Great Gossan Lode, in *Friendly* Mine 25° S. of W.	90.	S. 70-80°	2.5 to 3 fms.	Quartzose slate, quartz, earthy brown iron ore, and a vein of slaty clay on the N. *wall*.	.....	.....	.....	(*b*)
Lead Vein, (in *Primrose* Mine) 20° W. of S.	25.	E. 68-70°	1 to 1.5 foot.	Slaty clay, quartz, and a little galena.	Idem	*Gossan lode heaved* 5 feet L.G.A.		
	59.	E. 64-72°	4 to 8 inches.	Granular quartz, and galena...	Idem	*Lead vein heaved* 10 fms. R.G.A.	.....	*Tin lode heaved* 2 feet R.S.A.

The letters are employed to avoid repetition of the same descriptions. Owing to the form of the surface the adit is 50 fms. deep at *Friendly*, but only 25 at *Primrose*. The *back* of the Tin *lode* comes to the surface in the former.

WHEAL KITTY, PARISH OF SAINT AGNES.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
BOTTLE LODE, 35° S. of W.	50.	P. N. 85°	1.5 to 2 feet.	Quartz, chlorite, blende, oxide of tin, and copper pyrites. Many drusy cavities.	*Slate*, deep blue, thick lamellar; dip S.W. 50°.
KITTY LODE, 35° S. of W.	50.	N. 36–45°	2 feet.	Chlorite, quartzose slate, blende, iron and copper pyrites, and oxide of tin. The tin and copper ores occur together; and when one disappears, the other soon follows.	Idem; but rather paler coloured.

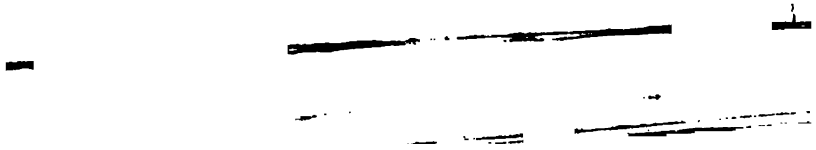
(Pl. IX. Fig. 7–8–8a.)

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Kernick's Lode.	Small Cross-courses. (*a*)
South Lode, 5° S. of W.	36.	S. 50–60°	2 to 3 feet.	Granular quartz, earthy brown iron ore, black and vitreous copper ore, iron and copper pyrites.	*Slate*, yellowish white, decomposing, soft; dip S.E. 30°: joints N. and S.		
	46.	S. 40–60°	3 to 5 feet.	Idem.	Idem, passing into bluish grey; dip S.E. 30°.		
	46.	S.E. 50–60°	1 to 1.5 foot.	Idem	Light blue; dip S.E. 14°	Idem	*Cross-courses heaved* 3 feet R.R.A.
The Two Cross-courses (*a*), 35° W. of N.	46.	N.E. 70–80°	4 to 6 inches.	Crystallized quartz. They are parallel in bearing and dip, and alike in all respects.	Idem	†	
Going's Cross-course N. and S.	76.	W. 70–80°	1 to 1.5 foot.	Crystallized quartz, in several veins.	Deep blue, in some places variegated; dip S.E. 35°: joints parallel to the *cross-course*.	*Lode heaved* 3 feet L.G.A.	

* The mines are worked on the same *lodes;* Tables LXXXI. and LXXXII. are therefore incorporated.
† A reference to avoid repetition.

WHEAL BUDNICK, PARISH OF PERRAN-ZABULOE. *(Pl. IX. Fig. 8b.)*

Name and Dtn. of vein.	Depth, fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Lead Lode.
Lead Lode. 30° S. of W.	34.	N.W. 70–80°	1 inch to 1.5 foot.	Where wholly in *elvan*, *elvany* clay; and, whilst touching the slate, some slaty clay also: in both cases mixed with oxide of tin.	N.W. *wall*, *elvan*, basis of felspar and quartz with a few crystals of felspar, and some schorl; decomposing, traversed by many joints bearing S.E. and N.W. In some spots the *elvan* occurs in the S.E. *wall*, also; but on that side it is mostly deep blue slate, of which the cleavage dips S. 60–70°.	
	44.	N.W.74° S.E. 80°	0.3 to 1.5 ft.	Granular quartz, slaty and *elvany* clay, with galena, blende, and spots of copper pyrites. In one spot an enormous mass of very rich oxide of tin accompanied the *lode* for several fms. in length, breadth, and height: it was of very irregular form, and stood on both sides of the *Lead lode*.	*Elvan*, very irregular in bearing, dip, size, and structure; it is, in some spots, but 4 or 5 feet wide, in others, 20 fms.; sometimes it is very fine grained, whilst elsewhere it consists of large distinct masses of felspar, and of quartz, with some schorl. Large lumps of slate are often imbedded in it; the line of junction between the two rocks is very distinct. Slate, deep blue, silky lustre; dip of cleavage S. 70–80; the joints bear N.E. and S.W. Several small veins of quartz traverse both the slate and *lode*.	
	46.	N.W.80° P.	6 to 8 inches.	W. Quartz, galena, and slaty and *elvany* clay. A vein of slaty clay carries the *lode* with it 6 feet L.G.A.	Idem.	
	54.	N.W.80°	1 to 2	E. Quartzose slate, and galena; in	S.E. *wall*, quartzose slate; N.W. side, decomposing elvan	



THE SAINT AUSTELL DISTRICT,

Is bounded on the south by a line drawn from Teague's Gate to the sea at Porth Pean; thence, in a north-easterly direction, by the coast as far as the eastern side of Par-sands; from the last place by a line extending northward to the top of Penpellick Hill: on the north it is bounded by a line from that hill to *Beam* mine; and on the west its boundary line is drawn from *Beam* to Teague's Gate.

It comprizes parts of the parishes of Saint Ewe, Saint Mewan, Saint Austell, Saint Blazey, Tywardreath, Lanlivery, Luxullian, Roche, and Saint Stephens.

In the north is the high granitic range of Hensbarrow* and its subordinate hills; and in the south are slate rocks, which, in some places, contain organic remains. *Elvan-courses* are numerous throughout the western part; and there is a small patch of serpentine in the cliff near Duporth.

The granitic formation here is of much greater extent than in any of the western districts. In general this rock possesses its ordinary character, and is rather coarse grained, and composed of felspar, quartz, and mica, and frequently much schorl also. In the northern, central, and eastern parts, however, it is sometimes very talcose and decomposing; and the sides of Hensbarrow supply nearly all† the

* Hensbarrow is 1026 feet above the sea level.
Trigonometrical Survey, I. p. 385.

† All—except a small quantity obtained from Towednack and Breage.
Ante, p.p. 17–44.

china-clay and *china-stone* sent from this county to the Potteries.

The micaceous and the talcose varieties are not mingled together, but seem to affect distinct beds; still there is not unfrequently a sort of transition between them. The talcose granite is commonly very much decomposed, and large tracts of it are entirely disintegrated.* When it is not so, if suffi-

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* "This granite, the felspar of which forms two-thirds of the mass, appeared "to me to be less decomposed near the borders of the plain, than in the central "part. In this last place it has rather the appearance of a porphyry with a "pulverulent base of a whitish colour, in which crystals of quartz, and some "plates of mica, are loosely included. It is used in this rough state in the "manufacture of porcelain * * * * * by mixing it in certain proportions "with the porcelain earth that is obtained by washing and frequent precipita-"tions." DR. BERGER, *Geo. Trans.* o.s. I. p. 125.

"Numerous excavations are made in St. Stephen's Moor, exposing to the "view a granite of a brilliant white colour intersected by contemporaneous veins "of quartz. On a near examination it is frequently found soft enough to be "cut with a spade, and is in that state packed up and exported to our potteries; "those parts only being rejected which are contaminated by the presence of "dark coloured mica. In other pits on the same moor, the rock is broken "down by mechanical force, and a running of water is made to pass through "the fragments. The finely attenuated particles of felspar are instantly taken "up and carried off in streams, as white as milk, which are collected in reser-"voirs; then pumped into cisterns; and evaporated, either by natural or "artificial heat. The beautiful white clay resulting from this process enters "into the composition of the finest earthenware produced in this country."

PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p.p. 104-5.

"China-clay is raised on the north of Carclaze, about one mile distant. The "soil is covered there by little quartz pyramids, as well as near Cligga Point, "and near St. Agnes Beacon. The clay pits are in a highly decomposed "granite, in which numberless double six-sided quartz pyramids are imbedded: "the contours of the crystals of felspar may be seen very easily in the greater "part of this granite; it must therefore be a granite decomposed *in sitû*, and "not deposited as an alluvium. The China-stone which is raised on the "western side of Tregonning Hill near Helston, is a granite in which the de-"composition has proceeded no further than to render the whole mass friable; "only one part of the felspar is changed into clay." M. M. VON OEYNHAUSEN AND VON DECHEN, *Phil. Mag. and Annals*, v. (1829) p.p. 242–3.

"The *china-stone* is a kind of granite, the felspar of which has undergone a "partial decomposition: it is carefully selected, so as to be entirely free from "shorl; and requires no other preparation for the *market*, than to be broken

ciently free from mica, schorl, tin ore, and other substances which impair its quality, it is quarried and exported as *china-stone.*

Over the more decomposed rock is passed a stream of water, which washes off the felspar-clay in a state of mechanical suspension; whilst the quartz and other impurities subside during the operation. The water holding the *china-clay* suspended is received in large pits,* where the clay falls down, and the supernatant water is allowed to escape when sufficiently clear. During unsettled and rainy weather the clay is not very quickly deposited; and then, if dispatch be desired, the subsidence is quickened by the addition of a solution of alum sprinkled in small quantities from a common garden watering-pot. When a layer of this mud 12 or 15 inches deep has been formed, it is either allowed to dry *in situ*, or removed to a higher reservoir.

I witnessed with surprize that clay, sufficiently consistent to stand in a heap, will rise through a common sucking pump worked by hand; though, when so drawn, it requires to be raked from the top of the pump.

" into a size convenient for carriage. This granite is of a peculiar nature: it " does not contain any mica, but numerous glossy scales of greenish yellow " talc. * * *

" These *china-clay works* are not confined to the parish of St. Stephens: " there are also many others in the parishes of St. Dennis and St. Austell; but " those of St. Stephens appear to be of a superior quality. The quantity of " *china-clay* exported from these places is very considerable, exceeding 7,000 " tons per annum; and when to this is added the amount of *china-stone*, which " is about 5,000 tons more, the whole forms a very important branch of com- " merce." Dr. Boase, *Cornwall Geo. Trans.* iv. p.p. 235-6-7.

* Locally called *pans.*

It is next allowed to harden by exposure, and, if the weather be dry, thus attains a proper firmness for exportation:* should, however, the season be unfavourable, after it has become coherent enough it is placed under cover, in order to its further drying. From this it will be understood that the washing the clay is mostly performed in winter, and the drying during the summer.

Being thus ready for the market, it is either packed in casks, each containing about half a ton, or removed in the lump. On the spot, twenty-five shillings per ton, or about three pounds and ten shillings when rendered in the Potteries, is considered a fair price.†

By scraping or cutting the surface of a piece of *china-clay*, the workmen can readily discover its former position in the pit with reference to the point

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* Dr. Boase has examined the composition of the *china-clay* of Breage and Saint Stephens and finds them to consist of:—

	Breage.	*St. Stephens.*
Silica — — — —	40.15	39.55
Alumina — — — —	36.20	38.05
Magnesia — — — —	1.75	1.45
Water — — — —	11.65	12.50
Insoluble residue (quartz and talc)	9.50	8.70
	99.25	100.25

Lond. and Edin. Phil. Mag. x. (1837) p. 350.

† The quantities of *china-clay* and *china-stone* exported from the County, in the year 1838, were:—

	Clay.	*Stone.*
Shipped at Penzance and the Mount, from Towednack, about — —	500 tons	
„ Breage „ — —		500 tons
„ St. Austell, St. Stephens, &c., shipped at Pentuan, Charlestown, and Par — —	20284 „	6844 „
Total —	20784 tons	7344 tons.

at which the stream of mud entered: for if scraped or cut in a direction coincident with that of the current, it presents a smooth surface; whilst it is very difficult, if not altogether impossible, to produce an even face if the force be applied in another direction.

Where foreign substances are so numerous and abundant, it may of course be expected that the *china-clay* will vary much in quality; but the whole of the clay procured from the same spot being conveyed into the same pit, there is little or no difference in this respect.

The granite throughout this district, but particularly that of the high grounds immediately north of Saint Austell, which is very talcose, is traversed by innumerable schorlaceous veins: the composition of these, and their relations to the containing rocks, are well known. These veins are generally of small size; sometimes they consist of schorl and quartz, at others of schorl and felspar, frequently of schorl alone, and occasionally portions of them are composed of quartz or of felspar only: usually, however, they are a mixture of all three substances, and most commonly abound in the oxide of tin. That ore is, notwithstanding, seldom confined to the veins alone, for it is generally also dispersed through the substance of the contiguous rock, into which, although the line of separation is mostly distinguishable, the veins frequently pass by imperceptible gradations.

On the whole they preserve a parallelism; but there are many exceptions, and in these cases they

often exhibit the ordinary phenomena of *heaves* and *throws;* when they unite they are often enlarged, and become proportionably productive.

They are generally so small, numerous, and closely connected with the rock,* that in many places they are "worked open to the day," as the tin ore contained in both rock and vein repays the expense of quarrying and removal. *Carclaze*† is the best

* At *Fatwork* mine, near the Indian Queens, the rock is a laminated mixture of felspar and schorl; but in many parts, and for some extent, the layers of felspar alternate with bands of tin ore instead of schorl.

† I have been favoured by Mr. Thomas with the following interesting account of the dimensions of this remarkable mine: from his own measurements.
"The excavation occupies 5 acres statute, and its depth is 136 feet; the solid "content is 63,000 cubic fathoms, and about one million tons have been "removed.
"The elevation of the surface at the northern side is 685 feet above high-water.
" southern — 670 — — —
" adit at the bottom of the mine 549 — — —

"A 3 quarts de lieue environ de la ville de *Saint-Austle*, est une montagne "peu élevée mais très-étendue, dont une partie forme ce que les Allemands "nomment *stockwerck* ou filon en masse. C'est un rocher de la nature du "granite de couleur blanchâtre & très friable, qui contient par-tout un peu de "minérai d'étain; il est entre-mêlé d'un nombre infini de petites veines noires "plus riches en minérai que le rocher lui-même: il en est où il est tout pur; "ces veines sont presque toutes paralleles & ont leur direction de l'*est* à l'*ouest*, "la partie du rocher où elles se trouvent quoique de la même nature que l'autre "est beaucoup plus dure, se détache néanmoins à coups de pic, & avec des "coins de fer.

"Cette mine s'exploite à jour comme une carriere sur une grande étendue."
M. JARS, *Voyages Métallurgiques*, (1765) III. p. 190.

"The enormous open work of Carglaze near St. Austell is an object of no "ordinary interest. The traveller may there see the operation of the miner "carried on in the light of day, without being compelled to descend a "hundred fathoms below the surface of the earth and then to crawl into a dirty "dripping cavern. The works are excavated in a variety of decomposing "stanniferous granite or schorl rock. Its chief constituents are quartz, felspar, "schorl, and oxide of tin, with occasional specks of mica. Throughout the "whole extent of the excavation, we may trace a succession of parallel veins "of schorl rock which do not in any degree partake of the decomposition of "the metalliferous beds, and appear both in their range and dip to correspond exactly with the beds of killas which are seen in the immediate "neighbourhood." PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p. 108.

"A fine view of tin lodes of both classes, and their intersections, may be

known instance of this mode, but the ***Bunny*** and ***Beam**** are equally remarkable.

" obtained at Carclase mine, near St. Austle, which is open from the surface. " The country is a decomposed granite, of a greyish white colour: the lodes " which are composed of quartz and schorl, being of a blackish colour, and " seldom more than six inches wide, the contrast is very visible. The lodes " of the oldest class are nearly perpendicular; some of them have a small " inclination towards the south: the more recent tin lodes underlie rapidly " southwards, and traverse the others."

MR. CARNE, *Cornwall Geo. Trans.* II. p. 92.

" The mine forms a large excavation, open to the day, and is said to be 250 " fathoms in length, 100 fathoms in breadth, and 21 or 22 fathoms in depth. " The direction of the greatest length of this remarkable opening is 30° N. of " W. In the eastern part of the excavation are several shafts sunk below the " bottom of it, by which tin ore is raised to a depth of 10 fathoms under the " adit. * * * * * * * * * * The granite of Carclaze is intersected by " numberless veins and strings of tin ore, and in the neighbourhood of which " the granite also contains tin ore. These veins consist chiefly of quartz and " schorl. * * * These tin lodes run in every direction through the granite, " but they are more prevalent in one direction than in any other, that is a direc- " tion 22° N. of W., their underlie is towards S., the angle they form with the " horizon is 35°. The distances between these veins is very short, they give to " the rock a stratified appearance. Other tin lodes run between 15° and 30° " E. of N.; they intersect the former tin lodes without heaving them, and also " without being heaved by them: it is said that very rich tin ores are found " where these different lodes intersect one another." M. M. VON OEYNHAUSEN AND VON DECHEN, *Phil. Mag. and Annals*, v. (1829) p.p. 241–2.

" In all the crystalline granitoid rocks of Cornwall there are also many " masses and " *veins of segregation.*" Such are the great contemporaneous " masses and veins of schorl rock; and some of these are metalliferous. The " decomposing granite of St. Austell Moor is traversed, and sometimes entirely " superseded, by innumerable veins of this description. Upon these lines of " schorl rock there is often aggregated a certain quantity of oxide of tin, which " sometimes diffuses itself laterally into the substance of the contiguous granite." PROFESSOR SEDGWICK, (*Address to the Geological Society, 18th Feb.* 1831.) *Phil Mag. and Annals*, IX. (1831) p. 284.

" Carclaze mine is *worked open to day*, like an immense quarry. The upper " part of the granite is much decomposed, but beneath it gradually becomes " more solid and perfect; it is traversed by innumerable *strings* and *bunches* of " shorl, and of shorl-rock, which abound in tin ore. These irregular veins are " evidently contemporaneous with the granite: for they are so intimately blended " together, that in order to obtain the ore both veins and rock require to be " *stampt* and washed." DR. BOASE, *Cornwall Geo. Trans.* IV. p.p. 238–9.

* " About two miles north of Carclaze is another tin-mine called Beam: it " is situated in the granite, and was originally *quarried*, but is now regularly " *mined.*" DR. BOASE, Ibid, p. 239.

" Like all the veins which traverse these hills, they (the *lodes* of *Beam*) are

Such veins are exactly similar to the tin veins in granite at *Balleswidden*,* and in slate at *Polberrow*,† and to the strings of copper ore in slate at *Wheal Music*, which have been already described.

On the outskirts of the granite are many interesting compounds of schorl with quartz, and felspar.‡ A fine grained mixture of quartz and schorl forms the much-admired Roche-rock,§ and a very beautiful variety, consisting almost wholly of quartz with radiating groups of schorl crystals, occupies the brow of Saint Mewan Beacon.‖

"composed of quartz and shorl, carrying more or less tin, which substances "are so united with the soft and hard growan, that not a doubt can be enter- "tained of their contemporaneous formation."

MR. HAWKINS, *Cornwall Geo. Trans.* IV. p. 476.

"On the south side of this moor they generally underlie to the south; but in "other places they are very nearly perpendicular, and at Bunney "open work" "they underlie north. The parallel stripes of schorl rock often part in the "middle, along narrow joints traced by oxide of tin. Tin is also disseminated "in regular crystals, both in the granite and schorl rock, where we have no "appearance of any regular vein distinguished from the rest of the formation. "In schorl the whole rock has a laminated or veined structure, produced by a "peculiar segregation of parts in passing from a state of fusion into a solid "state." PROFESSOR SEDGWICK *Geo. Trans.* III. N.S. p. 483.

See also Dr. Boase, London and Edin. Phil. Mag. VII. (1835) p.p. 379–450.

* *Ante*, p. 15. † *Ante*, p. 136, and Tab. LXXVII. ‡ *Ante*, p. 98, note.

§ The magnificent architectural decorations introduced by Mr Treffry into his residence at Place, are, for the most part, varieties of these rocks, and of the granite of this district. They are polished by a machine erected for the purpose at the *Fowey Consols Mines*. No description can do justice to their great beauty and variety.

‖ "The rock is formed of huge oblong masses, piled upon one another after "the manner of the granite tors; to which externally it bears an exact "resemblance. The constituents of this rock are both in distinct crystalline "granules: and white quartz intermixed with the black shorl produces a "good effect." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 242.

"On account of the prevalence of quartz in this compound, it may be "called quartzose shorl-rock. It is a very beautiful stone, and calculated "to produce a fine effect in ornamental architecture."

DR. BOASE, Ibid, p. 244.

As the granite nowhere reaches the coast, and as the mining operations on its junction with the slate are not considerable, the contact of the two rocks is not visible in many places.

At Trenance-bridge, near Saint Austell, the granite and slate meet in the bed of the rivulet; but as the stream is muddy with *china-clay* their junction can be observed only when the water is very low. The granite is fine grained and felspathic, and the slate deep blue, thick lamellar, and in some places micaceous, with an irregular cleavage which dips towards the south-east, whilst the line of contact bears about E. and W. The joints, generally, traverse both rocks without interruption.

In the cutting by which *Carclaze* is entered from the south, the granite and slate join, or rather pass into each other, through the medium of a compact rock mostly composed of schorl and felspar, which are sometimes mixed, at others in alternating laminæ; in some places, however, this rock is quartzose, whilst in others the quartz assumes a veined structure. The lamination of the rock inclines rapidly to the southward, and as the adit* is driven in this direc-

* Whilst mining operations were conducted with activity here, a stamping-mill, worked by steam, was erected at the very bottom of the excavation. This still remains, though it has been long disused; and several water-wheels, worked by streams collected from the neighbouring commons, now propel the machinery for crushing the stones loosened by the water as it flows down the sides of the cavity. Within memory the adit was navigable, and the ores were removed in a boat. The appearance is very singular, and without a parallel in the county.

" La facilitè qu'a le rocher de se détacher & de se réduire de lui-même en " sable, a fait imaginer de conduire dans cette carriere, à la profondeur de " laquelle on a pratiqué une galerie d'écoulement, des petits courans d'eau

tion without touching the granite, this dip of the transition must continue to a considerable depth.*

The slate of this district is included between the granite and the sea. It generally passes into that rock on the north, through masses of quartz, felspar, and schorl, in various modes of aggregation; and towards the coast it is fossiliferous.

The general character of the slate is fine grained, with a silky lustre, and schistose structure; the

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" (particuliérement en hiver & dans les tems humides), que l'on distribue sur " les endroits tendres du rocher qui se réduisent aussi-tôt en sable. Les " ouvriers agitent ce sable, de façon qu'il puisse être entraîné; mais comme le " minérai qui est répandu dans l'eau est extrêmement pesant, eu égard au " rocher, il se précipite dans le fond, d'où on le retire pour le laver sur des " pelles de fer où l'eau acheve de le séparer du rocher en passant par-dessus.

" Tout ce qui ne peut pas être détrempé par l'eau est cassé avec la masse pour " être ensuite transporté aux bocards; ce transport se fait par bateaux sur un " canal de demi-lieue de longueur, & qui passe sous terre environ 50 toises " pour arriver au fond de la carriere, deux toises au-dessus de la galerie " d'écoulement. On concevra du reste l'advantage & l'utilité de ce canal, si l'on " considere ce qu'il en coûteroit pour élever de 8 à 10 toises de profondeur per- " pendiculaire, l'immense quantité de minérais que produit ce *stockwerck*.

" On avoit commencé l'ouverture d'un second canal pour arriver à la profon- " deur de 12 toises au-dessous du premier, ce qui annonce une exploitation d'un " grand nombre d'années; le travail en est aisé, & l'on n'y emploie point de " poudre quoiqu'on y pratique quelques galeries pour suivre les veines miné- " rales les plus fortes. Les déblais ne gênent en aucune maniere, ils sont " entraînés par les courans d'eau; & quoique cette mine ne soit pas riche en " étain, l'abondance du rocher qui le contient & le peu de frais qu'occasionne " son exploitation, rendent cette entreprise très-bonne.

" Il y a toute apparence que la méthode d'exploiter cette mine comme une " carriere, n'aura lieu que pendant le tems que le minérai ne sera pas suivi " dans la profondeur. Le rocher qui est friable à la surface, & qui devient " plus dur en approfondissant, mettra dans la nécessité de la travailler comme " toutes les autres par des ouvrages souterrains."

M. JARS, *Voyages Métallurgiques*, (1765) III. p. 108.

* " This schorl-rock at the immediate junction seemed to pass into the slate " by almost insensible gradations."

PROFESSOR SEDGWICK, *Camb. Phil. Trans.* I. p. 108.

" The junction is nearly perpendicular, but dipping to the south; the killas " is decomposed into an earthy and argillaceous mass; but the stratification is " nevertheless distinct, the strata underlie rapidly to the south." M. M. VON OEYNHAUSEN AND VON DECHEN, *Phil. Mag. and Annals*, v. (1829) p. 241.

colour is usually blue, varying greatly in intensity, and the prevailing dip of the cleavage is towards the south-east. It is, in many places, quartzose, and often abounds in quartz veins.

At *Polgooth* the joints are filled with felspar clay, and this occurs also at *Pembroke* and *East Crennis*, and in many parts of *Fowey Consols*. At *Pembroke* the slate is of a dirty-white hue, passing into a reddish-brown.

A greenstone rock appears in irregular patches among the slate, in many parts of the district; as, for example, near Saint Mewan Church. On the road-side, between Saint Austell and Saint Mewan Beacon, there is a well-exposed section; the rock, which is much decomposed, appears to be a rather coarse grained mixture of felspar and hornblende, with traces of an irregular cleavage. It has been already stated that a laminated schorl-rock occurs near *Carclaze:* on the hill-side, towards Mount Charles, the common is covered with its *debris*, though the subjacent rock is there a reddish-brown slate, with alternating beds of a pale buff colour, and contains large quantities of mica.

At Apple-tree and Crennis beaches there are large quantities of encrinal stems;* and in a coarse grained

* These were first found by MM. De la Beche and Mac Lauchlan. I have discovered nothing but encrinal remains in this locality; but, at Par, Polkerris, Fowey, and Polruan, numerous specimens of turbinolia have been discovered both by Mr. Peach and by me.

From their imperfect state, and probably also from my own inexperience, I have been unable to assign their species, or to discover any which are precisely like them in the figures of Professor Phillips's Geology of Yorkshire; M. Goldfuss's Petrefacta Bonnensis; or Mr. Murchison's Silurian System.

arenaceous slate at Porth Pean, I thought I observed some obscure traces of organic remains.

In the cliff, at Duporth, a mass of serpentine rises through the slate; it is variegated, and consists of hornblende, or some similar dark-coloured mineral, apparently cemented by extremely thin layers of a very pale green steatite. Some portions are much decomposed; whilst others, though tending to disintegration, are still coherent.*

The only part of the district in which I have met with *elvan-courses*, is near *Polgooth*.† The largest of these, *Reskilling great elvan*, is extensively quarried for building purposes; it bears N.E. and S.W., dips N.W. 40-50°, and is from 3 to 8 fathoms wide. The *little elvan-course* runs 25° S. of W., dips N. 40–50°, and is about 2 fathoms in width. The direction of the *north elvan* is 20° W. of S., its dip E. 40–70°, and its breadth from a few inches to 2 fathoms; it throws off many veins into the adjoining slate.

In Clizey Hill two *elvans* are seen on the western side of the road, but only one on the east. The smaller is but a few inches wide, and is evidently a mere branch of the other, which bears S.E. and

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* "This rock, when polished by the sea, shews the manner in which its "component parts are aggregated. It is traversed by numerous veins of asbes-"tus, some of which are two or three inches in thickness: these for the most "part are situated at the joints between the layers of the rock. This mineral "is of a greenish colour, and consists of curved fibres that are not sufficiently "coherent to admit of their being separated."

Dr. Boase, *Cornwall Geo. Trans.* iv. pp. 280–1.

I could discover no *lodes* in contact with this serpentine; but the state of the cliff is not favourable for examination.

† An *elvan* at *Dowgas* is said to be in contact with a *lode* on each side; it was under water at the time of my visit.

N.W., is 10 to 12 feet wide on the east, but not more than 6 or 8 on the west of the road, and dips N.E. 50-60°. Its dip and direction coincide with those of the principal joints in the slate, but the inclination is contrary to that of the cleavage planes; most probably this is the continuation of one of the *Polgooth elvans.*

The composition of all is much the same; viz., a basis of felspar, quartz, and, in some places, of schorl, with large porphyritic crystals of pale buff and pink-coloured felspar. Some parts of the *Polgooth elvans* are traversed by minute veins of quartz containing tin ore.*

The directions of the *lodes*, in the greater part of the district, are a few degrees S. of W.; this is the case with several of the *lodes* at *Beam, Polgooth, Dowgas, Pembroke, East Crennis,* and *Fowey Consols.* There are, however, some others in *Polgooth* and *Fowey Consols,* and also the *lode* of *Charlestown Mines,* which bear nearly S.E. and N.W., and thus approximate to the directions of the *Caunter-lodes* in the western districts.

There are very few *cross-courses* and *cross-flucans.* At *Polgooth* a *flucan heaves* the *lodes* and *elvan* 30 fathoms: a similar one *heaves* the *lode* at *Pembroke* 7 fathoms:† at *Fowey Consols* there are also several *cross-courses,* but they are all inconsiderable.

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* Professor Sedgwick, (Address to the Geological Society, 18th Feb. 1831), Phil. Mag. and Annals, IX. (1831) pp. 283–4.

† It was believed that another large *flucan heaved* this *lode* 60 fathoms to the right, but more than 100 fathoms have been *driven*, and the *level* has been extended more than 40 fathoms under the sea at Short-horn without discovering the *lode*.

Some very unusual phenomena attend the intersections of the *lodes* and *elvan* at *Polgooth*.* *Saint Martin's* and *Screed's lodes* are both *heaved* by *Reskilling great elvan*;† an occurrence, as far as I know, without a parallel in the mining districts.

At Restormel, a large iron vein or *cross-course* bears about 15° W. of N., and dips E. 70–85°;‡ it is from 2 to 4 fathoms wide, and is generally in two branches, which include a mass of slate between them. The workings on it have been extended for more than two miles in length, but nowhere more than 10 fathoms in depth, and mostly not more than 3 or 4 fathoms. Its chief produce is brown, earthy-red, and hematitic iron ore, much mixed with quartz; but, in some places, it yields large quantities of the oxide of manganese. It abounds in *vughs*,§ which are lined with crystals of quartz, and of hydrous oxide of iron.

Almost the whole of the northern and western parts of this district yield only tin ore; but in the eastern portions of it copper ore prevails, which is generally in the state of copper pyrites; but native copper, the red oxide of copper, fahlerz, buntkupfererz, vitreous copper ore, and some of the still rarer

* Mr. Hawkins, Cornwall Geo. Trans. I. p. 143.

† A pretty little sketch of this spot may be found in the Saturday Magazine, II. (1834) p. 224.

‡ "A considerable quantity of this iron-ore has been exported within the "two or three last years; it having been found not only very productive, but "also of great advantage in facilitating the reduction of the clay iron ore: by "acting, no doubt, as a flux, its siliceous basis uniting with the alumina of the "other ore." DR. BOASE, *Cornwall Geo. Trans.* IV. p. 289.

§ The drusy cavities which are very common in the *lodes* are provincially called *vughs*, *vogles*, or *creegs*.

compounds of that metal, often finely crystallized, have also occurred at *Crennis, Pembroke, East Crennis*, and *Fowey Consols*.* In the last-mentioned mine the sulphuret of bismuth is very plentiful; generally crystallized in the cavities which are found in the copper pyrites.

The *shoots* or *bunches* of ore all dip from the granite; and as this rock lies mostly to the westward, the eastern parts of the mines are commonly the deepest.

This district affords more *stream-tin ore* than all the rest of the county: it always occurs in a rounded form, the masses varying from the size of the finest sand to several inches in diameter. At Pentuan,† the *tin-ground* was below the sea-level, and was chiefly covered by layers of sea-sand and shells. In the *stream works*, in the more elevated parts of the neighbourhood, the tin ore rests on the granite; and not unfrequently a second bed of tin ore reposes on the first, from which it is separated merely by a bed of disintegrated granite: and these are covered by two distinct layers of peat, having granitic gravel

* "These mines, including the late Lanescot mine, which has merged into "them, have realized and divided a profit amongst the fortunate shareholders "of £132,949 : 14 : 3 (to the end of 1837) after repaying the original outlay "expended in bringing the mines into a profitable state of working, together "with the machinery and materials now on the mines, which, with the balance "in hand for carrying on the same, exceed in value £50,000."

MR. DAVIS, *Mining Review*, IV. (31st July, 1838) p. 111.

The operations at the surface are well described in the Saturday Magazine, I. (1834) p. 40.

† Mr. Smith, Geo. Trans. IV. p. 404; M. Heron de Villefosse, De la Richesse Mineral, II. p. 354; and Mr. Colenso, Cornwall Geo. Trans. IV. p. 29.

between them, the whole being covered by depositions from the present streams.*

The scenery of this district is remarkable for its variety; the coast is indented by many retired sandy coves, and frequently bordered by highly-cultivated and well-wooded low-lands. The valleys which penetrate into the moors are often rich and beautiful, but the high-lands present the same characters of wildness and sterility which I have already so often described.

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* I have described these at some length, Cornwall Geo. Trans. IV. p. 60.

In company with M. Ström, of Bergen in Norway, I examined the valley which proceeds from the Luxullion stream-tin works to Par. On seeing the pebbles of the various schorl-rocks which occur in the bed of the river, he instantly recognized them as companions of tin ore, from their resemblance to the rocks which accompany that substance in the mines of Saxony and Bohemia, with which he had a long acquaintance.

DOWGAS MINE, PARISH OF SAINT STEPHENS.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Cross-course.
TREWITHEN LODE, S.E. & N.W.	35.	N.E. 68-74°	1 to 1.5 foot.	Quartzose slate, felspar clay, iron and copper pyrites.	*Slate*, deep blue; dip of cleavage N.W. 40-50°.	*Lode* intersected but not *heaved*.
TREWITHEN NORTH LODE, 20° W. of S.	35.	W. 65-70°	0.5 to 1.5 ft.	Quartz, slate, felspar clay, and oxide of tin.		
GREATSTOPES LODE, 20° W. of S.	35.	W. 48-60°	3 to 6 fms.	Slate, quartz, felspar, and slaty clay, iron pyrites, and oxide of tin.		
	—	W. 48-56°	--	Quartz, felspar clay, schorl, and oxide of tin.	Deep blue, curved and contorted, with much felspar clay between the laminæ: joints parallel to the *lode*, and N. and S.	
	—	W. 40-54°	3 to 5 fms.	Actynolite, hornblende, and felspar. It gradually shades off into the *Country*.	.....	*Lode heaved*, 4.5 fms. R.G.A.
SOUTH LODE, 20° W. of S.	35.	W. 20-30°	6 to 9 feet.	Slate, slaty and felspar clay, quartz, iron pyrites, and oxide of tin. At about 40 fms. deep it is said to unite with *Greatstopes lode*, and they do not again separate.		
CROSS-COURSE 10° W. of N.	35.	E. 60-68°	6 to 8 feet.	Crystalline and granular quartz, felspar, and slaty clay.		

In one part of their course all the *lodes* directly terminate, and are again found at about 4 fms. to the right at nearly right angles. No vein or joint of the rock occurs at this curious *heave*.

ND SAINT STEPHENS. (*Pl. IX. Fig. 9–10–11.*)

,	Flucan.	Little *Elvan.*	Reskilling Great *Elvan.*	St. Martin's Lode.	Screed's Lode.
and tra- veins joints *untry;* re filled leavage					
n. Fine z: near y small *de.*	*Lode heaved,* 30 fms. R.S.A. The vertical distance is about 19 fms. Pl. ix. Fig. 10. (‡‡)	The *lode* intersects the *elvan,* but does not *heave* it. Pl. ix. Fig. 11. (‖)			
S. ches the the two *lode* be- nd is re- ntact.	.....	.....	*Lode heaved,* or displaced, 7 fms. S.A. Pl. ix. Fig. 11. (¶)		
rl, and a se; dip					
.....	*Elvan heaved,* 30 fms. R.S.A.	.....	The two *elvans*	See above (‖)	

differences in the depth of the same *level* (gallery).

to avoid repetitions.

Dtn. of vein.	fms.	Dip.	Size.	Appearance [illegible]	Appearance of Rock.
Tin Lode, 35° N. of W.	38.	N.E. 55–65°	12 to20 feet.	N. side, a vein of earthy brown iron ore, quartz, and felspar, 6 to 12 feet wide; S. side, slate, quartz, ferruginous quartz, and oxide of tin, disseminated through the whole.	*Slate*, pale blue, soft, and fissile; near the *lode*, deep brown; dip of cleavage S.W. 20–35°.
	52.	N.E. 55–70°	6 to 8 feet.	Slate, quartz, ferruginous quartz, oxide of tin, and veins of quartz. The joints bear S.E. and N.W., and traverse both the *lode*, and *Country*. A vein, bearing E. and W., falls in with the *lode*, which is much richer in tin ore near the junction.	Idem.
	92.	N.E. 60–70°	8 to 10 feet.	Slate, quartzose slate, earthy brown iron ore, and oxide of tin.	Pale greyish blue, soft, and fissile; in some spots rusty brown near the *lode*.

Dirn. of vein.	Fms.			Appearance and Composition.	Appearance of Rock.	Remarks.
LODE, 8° S. of W.	28.	N. 74–82°	3 to 4 feet.	Granular quartz, felspar clay, slate, chlorite, copper and a little iron pyrites, vitreous copper ore, native copper, and carbonate of iron.	*Slate*, pale blue, passing into white, silky lustre, thick lamellar; dip of cleavage S.E. 40–45°. A few small veins and beds of quartz, with spots of native copper.	
	40.	N. 78–84°	4 to 8 feet.	Idem.*	Idem.	
	—	—	a line.	A mere line of native copper.....	Pale grey.	
	50.	N. 80–85°	6 to 8 feet.	Copper pyrites, and vitreous copper ore in large quantities, with chlorite, iron pyrites, and granular quartz.	Idem, very soft, and decomposing.....	*Lode heaved*, 7 fms. R.G.A.
	60.	N. 70–80°	6 to 7 feet.	Quartz, slate, chlorite, copper and iron pyrites, vitreous copper ore, and carbonate of iron.	Idem; dip S.E. 30–34°, with small quartz veins.	7 fms. —
	72.	N. 74–80°	4 to 6 feet.	Idem.	Idem; dip S.E. 44°.	
	85.	N. 72–77°	3 to 5 feet.	Granular quartz, felspar, chlorite, copper and iron pyrites, carbonate of iron, and spots of native copper.	Idem; dip S.E. 25–34°.	
	96.	N. 65–70°	3 in. to 4 feet.	Quartz, slate, and spots of iron pyrites...	Pale blue, decomposing; dip S.E. 40–44°, with spots of hard quartzose slate, much contorted, and containing felspar clay in the cleavage planes.	
	108.	N. 68–72°	3.5 ft.	Granular quartz, felspar, slate, chlorite, iron and copper pyrites.	Pale blue; dip S.E. 35–40°.	
	120.	N. 68°	1 to 1.5 ft.	Idem.	Idem, decomposing.	
FLUCAN, 20° N. of W.	60.	.....	6 in.	Slaty clay, with veins of friable quartz, and nodular masses of quartzose slate.		

* One branch of the *Great Flucan* (which consists of several veins, each *heaving* some distance) here touches the *lode*. The *heave* by that *Flucan* is said to be 60 fms. to the right.

Table LXXXVII.

EAST CRENNIS MINE, PARISH OF SAINT BLAZEY. *Pl. IX. Fig. 14.*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Cross-course or Flucan.
South Lode, (Main) 10° S. of W.	40.	S.	4 to 5 feet.	*Slate*, carbonate of iron, quartz, copper and iron pyrites. It is expected that the N. and S. *lodes* unite westward.	*Slate*, pale blue, thick lamellar; dip S.E. 34–36°.	
	50.	N.72-78°	2to6ft.	Quartz, and spots of copper pyrites.....	Joints parallel to the *lode*, and N. and S.	
	—	N. 70–80°	2 feet.	Copper pyrites, vitreous and black copper ore, and quartz.	Deep blue; dip S.E. 32–34°.	
	70.	N. 30–38°	3 to 5 feet.	Quartz, slate, blende, and copper pyrites..	Deep blue, passing into white; dip S.E. 60–65°.	*Lode heaved*, 7.5fms.R.S.A.
	80.	N. 48–50°	8 to 10 feet.	Slate, quartz, and copper pyrites.		
	90.	N.48-52°	2 to 6ft.	Idem.....	Deep blue, fissile; Dip S.E. 40–45°.	
	100.	N. 40–45°	2.5 to 3 feet.	Quartz, and copper pyrites.....	Idem; S.E. 70–75°.	
North Lode, 15° S. of W.	50.	S. 72–74°	2 feet.	Quartz, carbonate of iron, copper and iron pyrites, vitreous and black copper ore. Split into three *branches*:—	Fine grained, schistose, pale blue, silky lustre, with small veins of chlorite.	
	60.	S. 68–72°	4 in.	First; quartz, and spots of copper pyrites.	Compact, deep blue; cleavage dip S.E.; joints about N. and S.	
	—	—	—	Second; idem.		
	—	S. 72–78°	2 to 3 feet.	Third; quartz, and copper pyrites.		
	70.	S. 71–74°	—	Quartz, slate, and copper pyrites;—many *vughs*, lined with quartz crystals, & often studded with crystals of copper pyrites.	Pale blue, silky lustre, becoming white on decomposition; dip of cleavage S.E. 40°.	
	80.	S. 78-82°	2 to 3.5 feet.	Quartz, slate, and copper pyrites.....	Deep blue; dip S.E. 20-24°: traversed by veins of quartz.	
	90.	S.70–74°	—	Quartz, and copper pyrites.....	Pale blue, very schistose.	
Cross-course or Flucan, 35° N. of E.	70.	S.E. 70–72°	4 to 8 inches.	Slaty clay, with granular quartz in veins and spots.		

Table LXXXVIII.

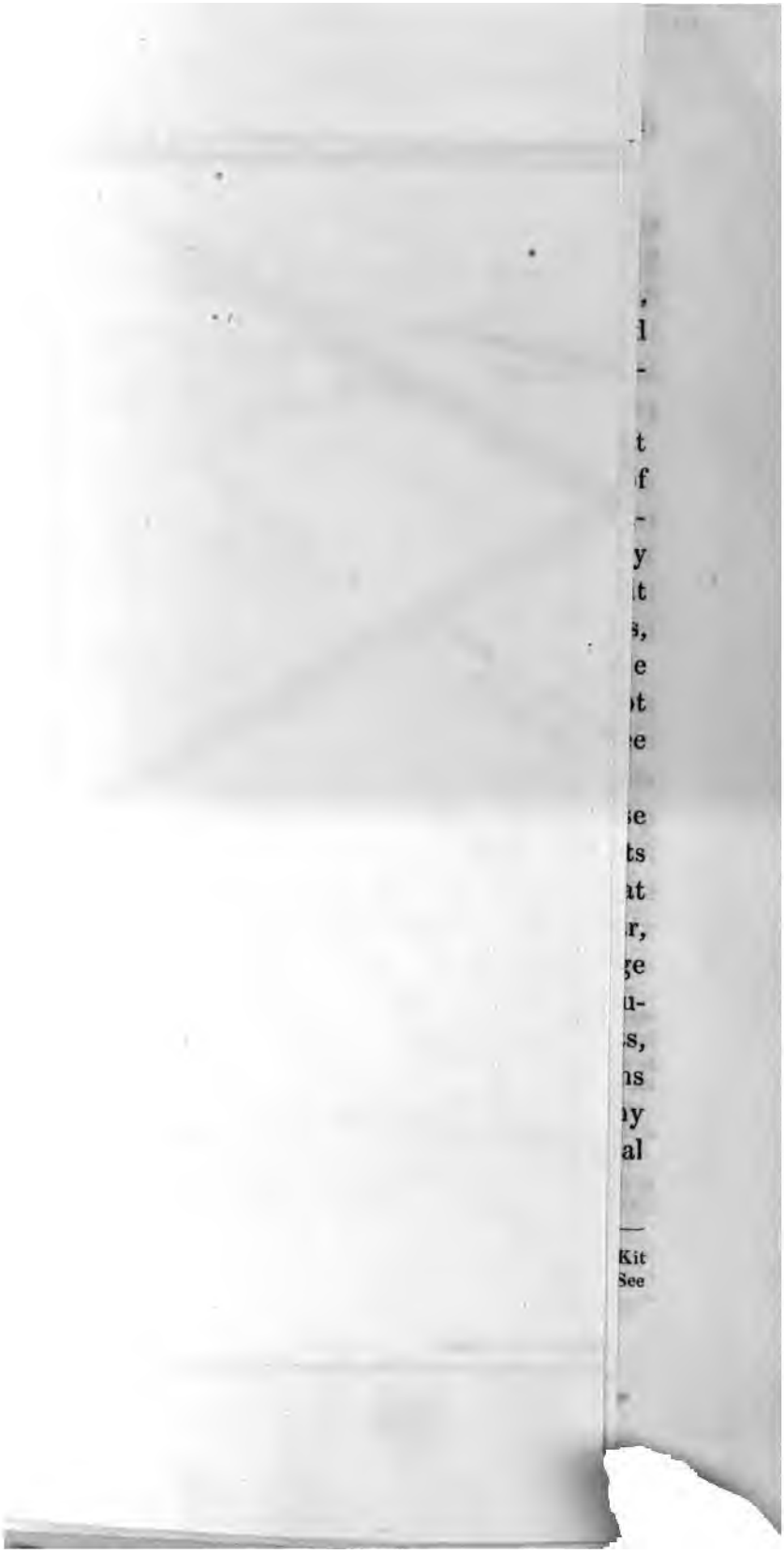
(*Pl. X. Fig. 1–2.*)

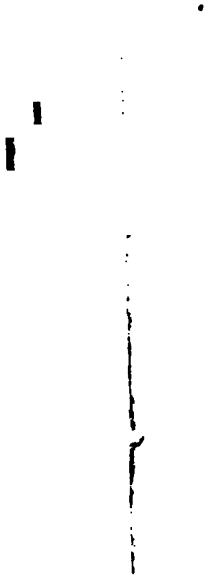
course.	Jeffery's Lode.	Crosspark Lode.	Ann's Lode.
raversed, t *heaved.*			
.....	*Bone's lode heaved,* 3 feet R,S.A.	*Crosspark lode heaved,* 4 fms. L.G.A.	
versed, eaved.‖			
aved, .R.A. — ¶			

Table XC.

Dtn. of vein.	fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	
North Lode, 16° W. of S.	20.	N.W. 60–70°	4 to 5 feet.	Disintegrated granite, felspar clay, schorl, and oxide of tin: in many small veins.	*Granite*, disintegrated, quartz, china-clay, talc, and schorl. At 3 fms. N.W. of the *lode*, it is very hard.	*Lode heaved*, 2.5 ft. R.G.A.
	62.	N.W. 50–62°	5 feet.	Disintegrated granite, wolfram, talc, and oxide of tin. There are three veins, on each side of either of which the oxide of tin stands in crystals; the intervals are filled with felspar clay.	Between the *North* and the *Middle lodes* but not in contact with either of them, is a mass of hard granite, 14 fms. wide, which rests abruptly against that which is decomposed. Hard granite S.E. *wall*.	
Middle Lode, 18° W. of S.	20 to 62.	N.W.60°	2.5 ft.	Minute veins of oxide of tin, and of schorl, in disintegrated granite, and china-clay.	Disintegrated granite.	
	62.	—	2 feet.	It here meets the hard granite, and then the oxide of tin at once disappears. Towards the N.E. it unites with the the *South lode*.	Hard granite.	
South Lode, 16° W. of S.	20.	N.W. 50–60°	5 feet.	Quartz, felspar, and veins of oxide of tin, and schorl.	Porphyritic and coarse grained, hard.	*Lode heaved*, 2.5 ft. R.G.A.
	62.	N.W. 52–60°	6 feet.	The *walls* coated with large crystals of oxide of tin, the intervening matter china-clay, wolfram, and talc.	Disintegrated granite.....	2.5 ft. —
	72.	N.W.60°	5.5 ft.	Felspar, talc, oxide of tin, a little black copper ore, and earthy brown iron ore.	..... Beneath this, the granite is very hard.	3 feet —
Cross-course N.E. & S.W.	20 to 62.	S.E. 60°	2 to 2.5 feet.	Granite, very quartzose, and porphyritic; generally hard, but in a few spots disintegrated.	Towards the N.E. there is a gradual transition from soft into hard granite.	
	72.	S.E.60°	3 feet.	Quartz, talc, and a very little oxide of tin.		

* Dr. Boase, Cornwall Geo. Trans. IV. p. 289; and Mr. Hawkins, ibid. p. 475.





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THE EASTERN, OR CALLINGTON AND TAVISTOCK DISTRICT,

Comprizes portions of the parishes of Callington, Stoke Climsland, Calstock, Tavistock, Buckland Monachorum, Sampford Spiney, Mary Tavy, Lydford, and North Bovey.

It consists of the two small granitic patches at Kit Hill and Gunnis Lake, and the western part of the Dartmoor granite, with the slate rocks contiguous to them. The most westerly granite is of very small extent, and merely forms the summit of Kit Hill;* the next, of somewhat larger dimensions, touches the Tamar near Calstock New-bridge: the eastern granite is that of Dartmoor, which does not reach so far westward as Tavistock by two or three miles.

Although all the granite of this district is coarse grained, and contains large felspar crystals, yet its texture is throughout considerably finer than that of the western tracts: its components are felspar, quartz, and mica, and generally too with a large proportion of schorl, which last is occasionally beautifully crystallized. Like that of the other districts, already described, it is frequently traversed by veins of schorl-rock and of quartz, and these, in many parts, afford tin ore, with which is mixed an unusual abundance of wolfram.

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* Dr. Berger, from his barometrical measurements, states the height of Kit Hill at 942, but the Ordnance Survey makes it 1067 feet above the sea. See Geo. Trans. o.s. I. p. 184, and Trigonometrical Survey, I. p. 384.

At *Birch Torr** there have been *open works* of some extent, on small veins like those at Saint Just, Saint Agnes, and Saint Austell, but, as they unite in depth, this mode of working has been long discontinued, and, as at *Beam*, it is now mined in the ordinary way with considerable success, and is at present the only *work* of any magnitude on Dartmoor.

On the very summit of Kit Hill there is, I presume, a similar formation. The mine† was stopped before my visit, and, of course, could not be examined: but I observed that fragments of the small schorl-veins in a greenish felspar, as well as tin ore and wolfram in fine distinct crystals, covered the surface.

The granite of this district has been very extensively quarried: that of Hey-tor is removed by a railway which reaches from the quarry to the waterside at Plymouth, whilst the stone from the fine quarry at Gunnis Lake is sent down by the Tamar: from Pu-tor the neighbourhood of Tavistock is supplied; and from Kit Hill, Callington and its vicinity.‡

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* This mine is several miles from any town or village, and, on account of the desolation of the place and the severity of the climate, is chiefly worked by labourers who have absconded from other districts for petty offences. So scanty is the accommodation, that in their few and wretched hovels, I am informed, the beds never cool; as soon as one occupant leaves, he is succeeded by another.

The machinery is worked by water, and in most winters is frozen up for several weeks.

† On this elevated spot a wind-mill was erected for draining the mine, and as the quantity of water, as usual in the granite, was small, the workmen were seldom inconvenienced by its accumulation in the bottom.

‡ "The eastern side of the Hingston granite is extensively quarried, to "within a short distance of the summit of Kit Hill, the most elevated part of "this range. In the upper part of these quarries, the granite is divided into "quadrangular masses by distinct and somewhat open joints, at which it is

Crystalline, compact, and lamellar schorl-rock occurs throughout the whole district;* as, wherever tin ores are abundant, it does in this country. I have not seen any junction of granite and slate in the district,† but the transition between them is, for the most part, through the medium of these schorl-rocks, which are compounds of schorl with quartz and felspar in variable proportions. At Roborough-rock a mixture of quartz and schorl occurs in large

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"somewhat discoloured by a partial decay: but as the quarries deepen the "stone becomes perfect, and the joints are no longer visible, though the rock "still separates into regular layers which are inclined towards the south. "* * It is traversed by veins of fine-grained granite, and by large quartz "veins frequently abounding in shorl, and sometimes with mica."

DR. BOASE, *Cornwall Geo. Trans.* IV. p. 221.

* "In some cases these rocks are compounds of decided crystals of quartz "and schorl; in others of granular combinations of the same ingredients; "sometimes of particles so minute, as to be difficult to distinguish by the aid of "a microscope, forming a hard, nearly black, stone; and mostly of this black "variety, striped and spotted with veins or crystals of white quartz, and some-"times with claystone or slate."

MR. PRIDEAUX, *Trans. Plymouth Institution*, I. p. 25.

† "Granite crowns the summit of Kit hill, which rises gradually from the "banks of the river to the height of 1400 (this should be 1067, see note, ante, "p. 131.) feet, and the same rock is to be found near the base of the mountain, "at Gunnis Lake Copper Mine, near New Bridge, and again a little higher up "the stream, at a place called the *Clitter*."

MR. TAYLOR, *Geo. Trans.* IV. p. 147.

"After crossing the new bridge, between Tavistock and Callington, to the "right bank of the Tamer, we again find the granite breaking out from under the "slate; the junction of the two rocks being exposed to view about 150 yards "down the river. The fundamental rock does not occupy a country of any "considerable extent; so that we reach its termination, and again descend to "the schist, at no great distance from its commencement."

PROFESSOR SEDGWICK, *Cambridge Phil. Trans.* I. p. 95.

"Just above the weir-head of the Tamar, is * * * Calstock Granite; * * "it is the easternmost point of a Cornish range; dips S.E. by S. about 20°; is "greyish white in the mass, small grained; of limpid quartz, black and brown "silvery mica, spicula of black schorl and grains of translucid tourmaline, with "some long rhombs of felspar, cemented together by the latter substance irregu-"larly crystallized. Reposing on this, south, is slate of a whitish yellow "colour, breaking into large rhombs; the laminæ having a nodular or uneven "surface, not clearly micaceous."

MR. PRIDEAUX, *Trans. Plymouth Institution*, I. p. 27.

quantities.* A similar kind of rock prevails, for a short distance, near both of the western patches of granite; but there it is in general soon succeeded by a pale brown, or buff-coloured micaceous slate, such as may be seen in the way-side near where the Stoke Climsland road leaves the Callington and Tavistock turnpike.†

The slate formation of this neighbourhood is of such extent and variety, and is so connected with rocks which have few if any relations to the metalliferous deposits, that I shall scarcely be able to give much precise information respecting it.

At *Redmoor*, on the west of Kit Hill, and at *Wheal Brothers* and *Wheal Saint Vincent*, on the east, the slate is a pale blue and thick lamellar, and dips S.W. in the first locality, and S.E. at the others. Near Haye there are some quarries of a deep blue roofing-slate; its laminæ dip S.W. and its joints bear nearly E. and W.

The slate which divides the Kit Hill granite from that of Gunnis Lake is probably only a thin superficial covering on the granite: it is coarse grained, micaceous, and of a brick-red colour, in some places compact, and in others very fissile. Many veins and beds of laminated and compact schorl-rock occur in

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* "It consists of quartz, slaty laminæ, iron ochre and schorl; forming a "caple of the miners, and appears to be a vein pervading the slate; * * * * "it runs nearly westward across the down, exhibiting the general dip of the "neighbourhood, though probably not twenty feet wide."

MR. PRIDEAUX, *Trans. Plymouth Institution*, 1. p. 80.

† Mr. Prideaux describes such a rock as in contact with the granite at Meavy, Shaugh, &c.,—Ibid, p. 23.

it, and the common is thickly strewed with their *debris*.

At *Drake Walls* the slate is deep blue, and of a silky lustre; several *lodes* have been worked in it, and have afforded large quantities of tin ore: the rock is everywhere traversed by small veins of this mineral, like those of *Polberrow*, the strings of copper ore in slate at *Wheal Music*, and of tin ore in granite at *Carclaze* and *Balleswidden*, which have been already noticed.

Subordinate to the same granite are the well-known Morwell-rocks, on the opposite side of the Tamar: they are in general of a hard quartzose hornblende slate, and dip towards the north-east.*

On the southern and western sides of Tavistock the slate is extremely fissile and decomposing, the cleavage dips S., and in general it has a purplish tint; it is well exposed by the cuttings in the Callington and Launceston roads, and near the toll-gate on the Moreton turnpike.

The shades of transition between this thin-bedded purple slate, and the dark blue slate which prevails at *Wheal Friendship* and *Wheal Betsy*† on the north-west, and at Grenofen, *Wheal Franco*, Crowndale, and *Virtuous Lady* on the south and south-east, are not discernable. At all these places the usual dip of the cleavage is S. and S.W., and the direction of the joints within a few degrees of E. and W.

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* "Morwell rocks, are very hard primitive slate, and having in some parts "a striated or fibrous, in others a sort of glimmering speckled appearance."
MR. PRIDEAUX, *Trans. Plymouth Institution*, I. p. 27.

† Mr. De la Beche considers that carbonaceous deposits occur here.—Report on the Geology of Cornwall, &c., p. 109.

Towards the Dartmoor granite there is commonly a massive crystalline hornblende rock,* which sometimes, but not often, contains a little felspar, and, in some places, granules of carbonate of lime. Cock's-tor is almost wholly composed of hornblende-rock, which is continued as far westward as Tavy Cottage and there is concealed by the vegetation. In general this rock is coarse grained and crystalline, and sometimes, though rarely, it has an irregular cleavage, as near Hazeldon. Opposite Ferrum Hill, in a quarry, it is fine grained and crystalline with an amygdaloidal structure; the contained mineral is carbonate of lime, which, mixed with quartz, also abounds in small veins, and is sometimes finely disseminated through the rock.

The same rock again appears at South Brentor, and there it also contains carbonate of lime; but this, where the rock is weather-worn, has been decomposed and dissolved, and the remainder, from its colour and appearance, obtains the local and not inappropriate name of *honeycombe-dun-stone.*

The nature of the connexion between the hornblende rocks, and the deep blue and purple slates, and between both of them, and the gritty, quartzose, thick-flaggy rock into which they respectively pass

* "It is almost pure hornblende, in different degrees of compactness, and "consequently, of specific gravity. At Cock's-tor, and White-tor it comes in "contact with clay-slate—at Brazen-tor, with granite. Clay-slate occupies "the western side of Cock's-tor, and forms a ridge near the summit, where it "comes in contact with the trapp. This ridge still preserves its laminar struc-"ture, but instead of its argillaceous aspect, has assumed that of flint, and "gives fire under the hammer. In many places it is become ribband jasper."
Mr. Prideaux, *Trans. Plymouth Institution*, i. p. 26.

on the western side of Black Down, are concealed by the soil.

A quartzose sandstone appears on Heathfield, and at Brentor it rises into the conical hill on whose summit stands the church* which is so conspicuous as a land-mark.

Where the weather has degraded this rock, certain globular masses seem to be less affected by decomposition, and in great numbers stand out in relief, although there is no other visible difference between them and that portion which has yielded to atmospheric action.†

An *elvan-course* occurs at *East Liscombe*, and may be traced in Morwell Down‡ a few yards north of the toll-gate (where it is much decomposed), and again in the bed of the Tavy, near where the waste-water from the canal falls into that river; its course eastward I have not pursued. *Elvan* is largely quarried on the road-side near Grenofen, and in several spots south of the Walkham river, on the

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* Notwithstanding this is an isolated hill, the churchyard is at times a complete swamp.

† "Brent Tor, north from Tavistock, is particularly remarkable, as a conglomerate there occurs some of the constituent parts of which have every appearance of volcanic cinders, an infiltration of siliceous and other matter having, during the lapse of ages, filled the vesicles of the cinders. The dip of the strata in that part of the country not being so considerable as it usually is in the district, these beds can be traced for some distance, and are observed to fine off in a remarkable manner into the arenaceous trappean rocks."

MR. DE LA BECHE, *Researches in Theoretical Geology*, p. 385.

‡ This is probably the northern series of porpheries B, D, F, in Mr. Taylor's Section of the Canal through Morwell Down, Geo. Trans. o.s. IV. p. 152, and Pl. VIII. See also Mr. Prideaux, Trans. Plymouth Institution, I. p. 29.

north-west side of Roborough Down; I am unacquainted with its westerly course.*

Not far from the water-course which crosses Roborough Down is another *elvan*,† long wrought for building materials.

All these appear to bear a few degrees S. of W., and the dip of the former two, (judging from Mr. Taylor's Section), is towards the north. They are mostly a mixture of felspar and quartz, and contain large crystals of felspar, and many small double-pointed ones of quartz, as well as a great deal of schorl: in the quarry at Grenofen there may be observed some mica also.

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* The direction would bring this directly in the line of Mr. Taylor's southern series of porphyries, K, M, N, in the Description and Section before mentioned. Mr. Prideaux describes (Trans. Plymouth Institution, I. p. 30.) a porphyry at Harewood, which is on the same run westward, but this I have not seen.

"In the valley through which the little river Walkham flows, and near the "point at which it falls into the Tavy, a remarkable change of strata occurs, "* * * a considerable cluster of detached masses of granitic rocks, which "are piled on each other in the most picturesque manner, form a lofty and steep "bank to the river.

"The situation of these rocks would point out a connexion between them "and some of the beds or veins of porphyry which are described as occurring "in the tunnel through Morwel Down; the line of their direction would lead "us to this point, and the inference is strong that it is a part of one of them."

MR. TAYLOR, *Geo. Trans.* O.S. IV. p. 147.

† "Running from nearly opposite Hoo Meavy to Bickham, is a bed of "singular porphyry, with no defined dip; bowlders of which are strewed "about the down so extensively, as to have acquired for it the name of 'Robo-"'rough Down stone.' It is almost white on fresh fracture, becoming brown "by the weather, and is full of small cavities, * * *. It is thinly dissemi-"nated with minute crystals of limpid quartz; and the cavities which appear "to be cubical when regularly formed, contain in some instances, remains of the "matter with which they were originally filled. The cement, forming nine-"tenths of the stone has an earthy fracture; yields, when scraped, a powder "sparkling with a micaceous aspect; and is very imperfectly fusible before the "blow-pipe. It is perhaps mica, in a very fine granular form; if such an "appellation be permitted."

MR. PRIDEAUX, *Trans. Plymouth Institution*, I. p. 30.

In the foregoing slight sketch of the rocks associated with the metalliferous deposits of this district, I have purposely abstained from all allusion to those on the south which are connected with the Plymouth limestone, and as much as possible from remarks on the arenaceous rocks of Brentor.

The directions of the *lodes* are generally a few degrees S. of W., but some of them bear rather N. of W. For the most part they dip towards the north, though a few have an opposite inclination.

Cross-courses are very numerous, and their *heaves* rather considerable: at *Wheal Betsy* and *Redmoor*, which are both in slate, they have yielded large quantities of galena, mixed with carbonate of iron.

In granite, tin ore is the chief product of the *lodes:* at Kit Hill wolfram is plentifully mixed with it, and at *Birch Torr* it is accompanied by large quantities of specular iron. In some parts of *Wheal Friendship* and in *Drake Walls*, which are wholly in slate, tin ore has occurred; but in the former it was not very abundant, and was attended by tungstate of lime.

Copper ores, chiefly in the state of pyrites, have been found in the *lodes* of *Wheal Friendship, Wheal Franco, Redmoor*, and *Wheal Robert*, which are all in slate: and also, formerly, in the same rock at *Crowndale, Wheal Crebor*, and other mines now abandoned. Native copper, the red oxide, green carbonate, and other rarer compounds of the same metal, with vitreous and black copper ore, have been abundant in *Gunnis Lake*,* which is worked in

* Fine crystals of uranite have been abundant in this mine.

granite. A sort of metalliferous bed, containing copper pyrites, with carbonate of iron, chlorite, and quartz, occurs at *Virtuous Lady** (Pl. XI. fig. 1): it bears about 20° S. of W., dips N. 10-15°, and varies from a few inches to 20 or 30 feet in thickness. The ores are distributed in the most irregular manner; sometimes large masses occur in the quartz, and soon split into strings; frequently these again expand, though not a few of them dwindle entirely away. Numerous ramifications of quartz extend into the slate, which near the bed contain many large and well-defined cubic crystals of iron pyrites, often imbedded in carbonate of iron. The workings on the south open to the surface, and their dimensions underground are about 100 fathoms long by 80 wide, the greatest depth is 15 fathoms. The cleavage of the slate in which it occurs dips S.

Galena, mixed with vitreous and red silver ore, and with native silver, has been found in the *lodes* of *Wheal Brothers* and *Wheal Saint Vincent.*

About a mile S.W. of Callington the oxide of manganese has been much sought for, but with little

* For the variety and beauty of its specimens it surpasses any mine in the district: carbonate of iron is here found in the spathose form, and in hollow cubes formed on fluor, as appeared by a specimen still retaining that substance, which was shewn me by Captain Martyn; these again are lined with crystals of quartz, and studded with those of copper and iron pyrites. A most remarkable form of the carbonate of iron is peculiar to this mine: it consists of thin plates the ends of which have the figures of pointed arches, and their edges are usually covered with crystalline groups of the same mineral, which seem like ornamental borders. The carbonate of iron usually presents a crystalline face on one side, whilst the other is smooth, and seems as if moulded on some other substance: both sides and angles are spangled with crystals of iron pyrites. The plates are from 2 to 8 inches long, and they intersect each other in the most irregular and capricious manner.

Small crystals of an undescribed compound of titanium are also abundant in he chlorite.

success: the rock is a crystalline mixture of hornblende and felspar. At Hogg's-tor, in the parish of Milton Abbot, however, in the neighbourhood of a similar rock,* this mineral has been raised in very large quantities: the ore is in short, irregular, vein-like patches, mostly accompanied on either side by veins of felspar-clay. Some manganese has also been found on the south of Brentor, but it is understood to have occurred in irregular and unconnected masses.

Iron ores are procured in abundance at Shaugh, and near Walkhampton.

Stream-tin ore is still found in small quantities on Dartmoor, accompanied, as usual in the western streams, by minute grains of gold; but I am not aware that there is anything peculiar in its mode of deposition,

Except its rugged cairns† nothing relieves the dreary monotony of Dartmoor:‡ the roads over it

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* "The numerous situations in Devon and Eastern Cornwall, where bundles "of manganese occur, are, with very few exceptions, and many of these some-"what doubtful, in grauwacke, near greenstone or some trappean rock."

MR. DE LA BECHE, *Researches in Theoretical Geology*, p. 219, note.

† A logan-rock at Staple-tor is very remarkable, as it requires the application of a counterpoise in order to its being moved by ordinary human force. See Mrs. Bray's Borders of the Tamar and Tavy, I. p. 240.

‡ "In the year 1752, on the 23rd day of February, a smart shock of an "earthquake was felt at many places on the moor, and in its immediate neigh-"bourhood—Manaton, Moreton Hampstead, and Widdecombe. In the last-"named village some houses were injured, and one of the pinnacles of the "tower of the church was thrown down." Ibid, p. 310.

On Friday the 20th of October, 1837, at about 2 o'clock in the afternoon, a similar shock was experienced at Camelford, North Hill, and Liskeard, in Cornwall; and at Mary Tavy, Peter Tavy, Buckland Monachorum, and North Bovey, in Devon. In all cases there was a tremulous motion of the earth; in some spots the windows of the houses were shaken, and in others the earthen-

are few, and the mists (locally called *gollars)* so frequent and dense, that tourists usually content themselves with its outskirts, and seldom visit its recesses: where its peat-bogs and morasses, which seem to be principally formed on elevated grounds, yield abundance of excellent fuel, and its rills and marshes afford shelter to the young of the snipe, the wild-duck, the teal, and other wild-fowl. It, however, gives plentiful summer pasture to sheep and young cattle.

But the most varied and enchanting combinations of hill and dale, wood and water, adorn the low-lands and vales; and neither language nor even the pencil can do justice to their exceeding beauty.

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ware and glass on the shelves were jingled together. At Camelford, Mary Tavy, and Peter Tavy, it was accompanied by a sound which was described by some as resembling that of a heavy cart, and by others as like the rattling of stones. The labourers underground in *Wheal Friendship*, *Wheal Franco*, and *Birch Torr*, were alarmed by a noise which they imagined to have proceeded from the destruction of the pumping machinery, or the falling together of the mining excavations, and left their work in dismay. The weather at the time was unusually clear and serene. No displacement of the rocks, or veins, or other consequences appear to have attended. See the Cornwall Royal Gazette newspaper, 27th October, and 3rd November, 1837.

A shock of an earthquake is said to have been felt at the Scilly Islands on the 21st January, 1839, and an account of it, by the Rev. George Woodley, was read before the Royal Society, on the 7th February, 1839.

WEST REDMOOR MINE, PARISH OF CALLINGTON.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
Lode, 15° S. of W.	12.	N. 40–50°	6 to 8 feet.	Carbonate of iron, quartz, iron pyrites often crystallized, with large irregular masses of slate. The crystals of iron pyrites are most numerous in the joints.	*Slate*, deep blue, silky lustre, thick lamellar; dip of cleavage S.W. 20–24°. Joints parallel to the *lode*, and N. and S.,—the latter traverse both slate and *lode*.
	18.	N. 40–45°	0.5 to 2 feet.	Quartz, iron pyrites, and slaty clay, with numerous small veins of mica.	Deep blue; dip N. 20–28°.
					An *elvan-course* bears 28° S. of W., and is 18 fms. wide; its N. *wall* dips N. 28°, and S. *wall* N. 10°. It consists of a basis of felspar, quartz, and a little mica, with large crystals of white felspar.
					Slate, N. dark blue; dip S.E. 16°; the joints are common to both rocks.

REDMOOR MINE, PARISH OF STOKE-CLIMSLAND. (*Pl. X. Fig. 4.*)

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Lead Lode or Cross-course.
JOHNSON'S LODE, 10° N. of W.	19.	S. 68–72°	2 to 4 feet.	Quartz, slate, spots of oxide of tin, and of copper pyrites.	*Slate*, pale greyish blue, silky lustre, rather decomposing; dip W. 20–24.	*Johnson's lode* divided, but not *heaved.*
	29.	S. 66–74°	3 to 5 feet.	Idem.....	Idem, thick lamellar.....	Idem.
	39.	S. 40–45°	2 feet.	Idem.....	Idem, the joints bear N. and S., and parallel to the *lode.*	*Johnson's lode heaved,* 5 feet L.G.A.
GREAT GOSSAN LODE, 5° S. of W.	18.	N. 60–68°	4 feet.	Iron pyrites, quartz, and slaty clay, oxide of tin, and spots of copper pyrites.	Idem.....	*Great Gossan lode* divided, but not *heaved.*
TRELEASE'S LODE, 5° S. of W.	18.	N. 60-70°	3 to 4 feet.	Quartz, and slaty clay.....	Idem.....	*Trelease's lode* divided, but not *heaved.*
	38.	N. 68–74°	1.5 to 2 feet.	Slate, quartz, spots of oxide of tin, and of copper pyrites.	Idem; dip W. 20–24°.	
	—	N.	a line.	Felspar clay.....	An *elvan-course,* composed of fine grained felspar, and quartz, with a little schorl, bears E. & W., and dips N. 20–40°; it is 9 fms. wide, and *Trelease's lode* dwindles to a mere string in it.	
LEAD LODE OR CROSS-COURSE 8° E. of N.	18.	W. 60°	....	N. Several veins of slaty clay.....	Slate, pale greyish blue, thick lamellar; dip W. 20°.	
	19.	W. 60–68°	2 feet.	S. Slaty clay, quartz, iron pyrites, and galena.	Idem.	
	29.	W. 68–74°	1 in. to 2 feet.	Granular quartz, slaty clay, galena, and a litle carbonate of iron.	Idem.	
	90.	W. 60–70°	1 in. to 1.5 ft.	Idem: in some places split into *strings.*	Idem.	

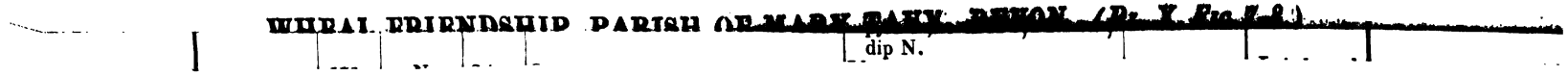
WHEAL BROTHERS, PARISH OF CALSTOCK.

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
Lode, 24° S. of W.	16.	S. 42°	1.5 to 2 feet.	Decomposed slate, granular quartz, blende, iron pyrites, carbonate of iron, native and vitreous silver.	*Slate*, pale blue; dip S.W. 28–32°, much decomposed, and traversed by quartz veins.
	—	S. 46–48°	—	Quartz, felspar clay, galena, carbonate of iron, red, vitreous, and black silver ore, and native silver.	Idem, with large quantities of white mica.
	26.	—	10 in. to 3 feet.	*Walls* smooth. Slaty clay, quartz, iron pyrites, carbonate of iron, with small cavities lined with native, vitreous, red, and antimonial silver; small irregular masses of galena, blende, and copper pyrites.	Pale blue, decomposing, quartzose, with much felspar clay; dip S.E. 20–34°.

Table XCIII.

WHEAL FRANCO, PARISH OF BUCKLAND MONACHORUM, *DEVON.* (*Pl. X. Fig. 5–6.*)

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Main Lode.
Main Lode, 25° S. of W.	16.	N. 40–50°	4 to 5 fms.	E. of eastern *cross-course*. Quartzose slate, earthy brown iron ore, a little copper pyrites, and oxide of tin.	*Slate*, pale blue, thick lamellar; N. of *lode* dip of cleavage S.W. 10–14°; S. dip S.W. 40–44°.	
	—	N. 48–56°	2 to 3 fms.	W. Copper and a little iron pyrites, quartz, and quartzose slate.	Deep blue.	
	26.	N. 50–56°	2 to 2.5 fms.	Quartz, slate, iron pyrites, spots of copper pyrites, and oxide of tin.	W. of western *cross-course* dip S.W. 50–58°. E. of eastern *cross-course* cleavage horizontal.	
	56.	N. 50–54°	1.5 fm.	W. of western *cross-course*. Quartz, slate, and a vein of copper pyrites on N. *wall*.	Deep blue, curved, quartzose, and irregular.	
	—	N. 48–56°	1 to 2.5 fms.	E. of western *cross-course*. Quartz, fluor, and spots of iron and copper pyrites.		
	60.	N. 42–48°	1.2 to 2 fms.	Quartz, quartzose slate, fluor, and a vein of copper pyrites on the N.	Deep blue, silky lustre, curved and irregular; dip S.W.	
Western Cross-course 25° W. of N.	16.	E. 75–85°	4 to 6 feet.	Veins of slaty clay on each side, with quartz between them.	Idem	*Lode heaved*, 11 fms R.R.A.
	26.	E. 80° P.	5 feet.	Slaty clay mixed with granular quartz.....	.....	11 fms. —
	50.	E. 68–74°	—	A vein of crystallized quartz, with some slaty clay.	.....	11 fms. —
Flucan, or Caunter, 20° N. of W.	16.	N. 80–86°	2.5 ft.	Slaty clay.....	Deep blue.....	*Lode heaved*, 10 fms R.G.A.
	50.	irregular.	1 in. to 3 feet.	Idem.....	Idem.....	20 fms. —
	60.	N. 80–85°	2 to 4 feet.	Idem, curved, with many unctuous faces....	.....	20 fms. —


WHEAL FRIENDSHIP PARISH OF MARY TAVY, DEVON. (Pl. V. Fig. 1.)
dip N.

WHEAL BETSY, PARISH OF MARY TAVY, *DEVON.* (*Pl. X. Fig. 9–10.*)

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.
Lode,* 4° W. of N.	12.	W. 70–74°	2 feet.	Quartz, slaty clay, and carbonate of iron.....	*Slate*, deep blue; dip of cleavage N.W. 8–12°.
	24.	W. 54–62°	1.5 to 2.5 ft.	Quartz, and slaty clay.....	Pale blue; dip W. 20°.
	36.	W. 40–50°	3 feet.	Quartz, earthy brown iron ore, carbonate of iron, and a little galena.	Idem; dip N.W. 30–40°.
	48.	W. 70–76°	2.5 ft.	Quartz, carbonate of iron, and galena.....	Deep blue, traversed by many small veins of quartz; dip N.W. 40°.
	57.	W. 60–70°	1.5 ft.	Idem.	Idem.
	69.	W. 60–68°	—	Crystallized quartz, carbonate of iron, and galena..	Idem; dip S.W. 12-20°.
				In two *veins.*	
	82.	W. 70°	6 in.	E. *vein.* Crystallized quartz, carbonate of iron, and galena.	Idem.
	—	W. 80°	—	W. *vein.* A small vein of galena, quartzose slate, crystallized quartz, and carbonate of iron.	Idem; dip N.W. 12–16°.
	92.	W. 70-80°	6 in. to 3 ft.	Slate, quartz, carbonate of iron, galena, and a little blende.	Idem.
	102.	W. 60–70°	1 to 1.5 ft.	A vein of galena 7 inches wide, quartz, and quartzose slate.	Idem, very quartzose.
	—	W. 70°	1.5 to 2 feet.	Slaty clay, galena, and quartzose slate.	

* This *lode* is considered to be the northerly prolongation of the eastern *cross-course* in *Wheal Friendship.* Table XCVI.

BIRCH TORR MINE, PARISH OF NORTH BOVEY, *DEVON.*

Name and Dtn. of vein.	Depth. fms.	Dip.	Size.	Appearance and Composition.	Appearance of Rock.	Cross-course.
LODE, 20° W. of S.	25.	W. 72–74°	2 to 3 feet.	Quartz, dark grey felspar, schorl, and oxide of tin.	*Granite*, fine grained, quartz, felspar, and schorl, with a little mica.	
	52.	W. 72–80°	1 to 2.5 feet.	Quartz, granitic clay, earthy brown iron ore, and specular iron.	Fine grained schorl, and quartz.....	*Lode heaved*, 3.5 ft. R.R.A.
					Red felspar, quartz, a little mica, and schorl.	
					Red, and white felspar, and quartz.	
	65.	W. 78–84°	1 in. to 2.5 ft.	Quartz, specular iron, earthy red iron ore, disintegrated granite, and oxide of tin.	Fine grained schorl, quartz, and a little mica; crimson felspar, and quartz, abundant.	3.5 ft. —
	—	—	1.5 ft.	Quartz, specular iron, and earthy brown iron ore.	A few large porphyritic crystals of felspar, compact felspar, and schorl.	
CROSS-COURSE 20° N. of W.	52.	W. 72–74°	7 to 10 feet.	Red felspar, quartz, much schorl, and a little mica.		
	65.	P.	.....	Red felspar, quartz, and schorl. All the joints contain felspar clay.		

Fig 4.

PLAN OF

EDMOOR MINE

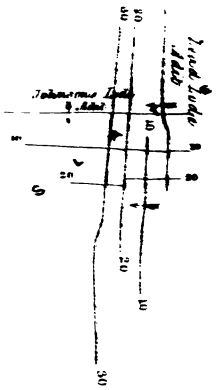


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Fig. 3.

PLAN OF

BEAM MINE

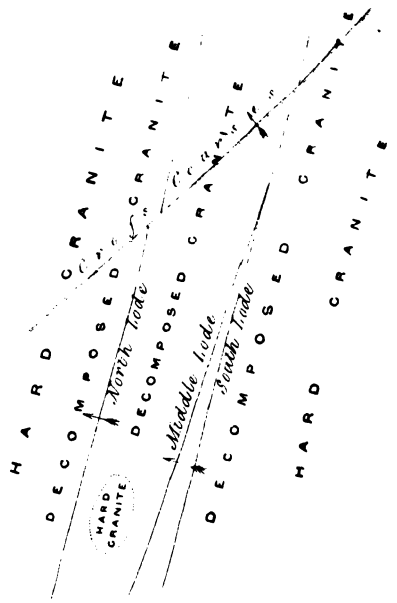

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Fig. 4.

PLAN OF

REDMOOR MINE

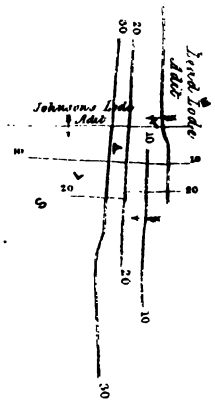

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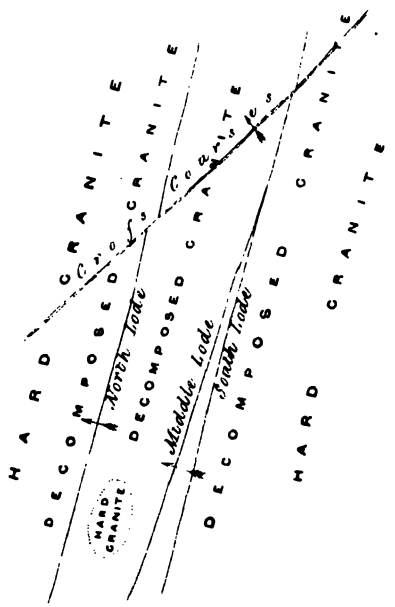
Fig. 3.

PLAN OF

BEAM MINE



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RECAPITULATION.

ıe object of this Paper is to describe the
'erous deposits, I abstain from taking more
of the rock-formations of the country than
ɛlations to the veins render indispensable:
o so the more readily, as the admirable pub-
s of my friend Dr. Boase on the Geology of
ıll generally,[1] as well as the excellent Memoirs
'essor Sedgwick[2] and others on various por-
it, the outline contained in Mr. De la Beche's
rt,"[3] and the observations in the preceding
ıave rendered further details less necessary.

THE GRANITE.

e are five principal masses of granite of large
viz., 1st, in the Saint Just and Saint Ives
ɜ; 2nd, at Gwennap, Crowan, &c.; 3rd, in
nt Austell district; 4th, at the Bodmin
and 5th, Dartmoor. The same rock also oc-
nine smaller tracts; viz., 1st, Saint Michael's
2nd, Tregoning and Godolphin Hills; 3rd,
ɜrea; 4th, Cairn Marth; 5th, Cligger-point;

1 Geo. Trans. iv. p. 166, and Primary Geology: London, 1834.
2 Cambridge Phil. Trans. i. pp. 89-291.
on the Geology of Cornwall, Devon, and West Somerset: London,
ɜ publication reached me (Feb. 1839), whilst my observations on the
ɜtrict were passing through the press.

6th, Belovely Beacon;[1] 7th, Castle-an-Dinas;[2] 8th, Kit Hill; and 9th, Gunnis Lake.

At great depths all these are probably united, as in every case, except that of Cligger-point, their dimensions enlarge, and they spread out beneath the slates as they descend: they have, therefore, been appropriately likened to islands of granite rising out of an ocean of slate.[3] The peculiar appearances at the junctions of the two rocks will be presently noticed; here it is sufficient to mention that beds of granite sometimes interlie, and veins of it penetrate the slate in all directions, but in general these are of small size, and seldom continue far from the central granite.

The composition of the granite and of the massive rocks subordinate to it, and with which it is associated, is very various; but, in all, the principal ingredient is felspar, generally united with quartz, and mica, and often with schorl. Talc and chlorite are occasionally substituted for these last.

The ordinary structure is an irregularly crystalline basis of felspar, quartz, and mica, mostly with some schorl also, and enclosing large and distinct (porphyritic) crystals of felspar. The Cornish granite is, for the most part, coarse grained, but in this respect it differs considerably in various places; for example, that of the Saint Just[4] and Saint Ives[5] districts has a much coarser texture than any other, whilst at Tregoning and Godolphin Hills[6] it is usually

[1] Mr. De la Beche, Report, p. 156. [2] Ibid, p. 156. [3] Dr. Boase, Cornwall Geo. Trans. iv. p. 365. [4] *Ante*, p. 7. [5] Ibid, p. 16. [6] Ibid, p. 43.

much finer. In the other tracts the granite is porphyritic, but the crystals of felspar are much smaller than in the western districts.

In the immediate vicinity of the *lodes* at *Parknoweth*,[1] *Wheal Cunning*,[2] *Balnoon*,[3] the *Saint Ives Consols*,[4] *Great-work*,[5] *Dolcoath*,[6] *Cook's-kitchen*,[7] *Wheal Buller*,[8] and at some other places, the portion of felspar in the basis is not unfrequently an ash-green colour, sometimes of buff, fawn, or pale pink, and now and then of a deep crimson, passing into brown; the enclosed crystals have also some of these hues, but the basis and the crystals are seldom of the same tint; and the bounding-planes of the crystals are not, in such cases, well defined. In other spots the felspar, both of the basis and of the included crystals, is of a pearl-white colour.

Crystals of mica and of schorl are sometimes contained within those of felspar; and where a large plane surface of coarse grained granite is exposed, it is by no means uncommon to find some uniformity of position in the arrangement of the felspar crystals, which may have been assumed by some influence of polarity at the moment of solidification. At *Wheal Union*,[9] and *Saint Ives Consols*,[4] there are examples of this kind

In the ordinary varieties of granite the quartz and mica, though crystalline in their characters, seldom assume definite forms: the former is in general pellucid or pearl-white; and the latter,

[1] Table vi. [2] Table iii. [3] *Ante*, p. 24. [4] Table xvi. [5] Table xliii [6] Table l. [7] Table li. [8] Table lviii. [9] Table xv.

white, brown, or black. Schorl accompanies every variety of our granites, and may be detected in them in numberless places, often in the form of veins, but frequently also in distinct crystals aggregated in radiating groups, and sometimes in large irregular lumps. At *Wheal Buller*[1] chlorite appears to replace the mica, and at *Wheal Spearn*,[2] *East Wheal Damsel*,[3] and *Stenna Gwyn*,[4] fluor enters into the composition. At Sancreed, Towednack,[5] Breage,[6] and in the Saint Austell district,[7] talc, in a great measure, takes the place of mica. This variety is in general much more decomposed than the ordinary granite;[8] it is quarried as *china-stone*, and prepared as *china-clay*, the processes for which I have already described.[9] Tin ore is distributed through the granite at *Balleswidden*,[10] Raggy-rowal,[11] *Wheal Vyvyan*, Cligger-point,[12] the *Bunny*,[13] and *Carclaze*,[14] and becomes one of the ingredients of the rock; and pinite is common throughout the Saint Just district.

The common coarse grained (porphyritic) granite is frequently traversed by veins of a similar substance, but much finer texture, as at *Wheal Cunning*,[15] *Park-noweth*,[16] Saint Levan,[17] and Stythians;[18] these

[1] Table lviii. [2] Table x. [3] Table lxiv. [4] In the Parish of Saint Stephens. [5] *Ante*, p. 17. [6] Ibid, p. 44. [7] Ibid, p. 116.

[8] Dr. Turner's Lecture on the Chemistry of Geology, London and Edinburgh Phil. Mag. iii. p. 21.

This fine grained granite is provincially called *whet-stone*, but in the Saint Just district it is designated *gollan*.

[9] *Ante*, p. 117. [10] Ibid, p. 15. [11] Ibid, p. 53. [12] Ibid, p. 94. [13] Ibid, 121. [14] Ibid, p. 119. [15] Table iii. [16] Table vi.

[17] Mr. Carne, Cornwall Geo. Trans. iii. p. 216: MM. Von Oeynhausen and Von Dechen, Phil. Mag. and Annals, v. (1829) p. 245: Dr. Boase, Treatise on Primary Geology, p. 21: and Mr. De la Beche, Report, p 171.

[18] *Ante*, p. 69.

are usually small, and are curved, contorted, and in all respects irregular. Unconnected spheroidal concretions of the same structure, and of fine grained schorl-rock, are also often imbedded in it.

Veins of schorl, associated in some places with felspar, and in others with quartz, and often containing tin ore, traverse the granite of every mining district, but these are, in general, far the more abundant near its junction with the slate. In such places, indeed, there prevails a sort of transition between the two; in the granite the proportion of mica becomes less, and that of schorl increases: and this schorlaceous rock sometimes consists of schorl and quartz, and again of schorl and felspar, and often assumes a veined structure.[1] This veining, on a large scale, passes into a thick lamellar structure, which now and then becomes schistose, but more frequently, for some distance, retains the large bedded appearance: as at *Carclaze*.

Not uncommonly, however, just on the line of junction, the granite becomes extremely fine grained, and appears to contain but little quartz: the slate, on the other hand, is massive, and is merely distinguishable from the granite by the colour, which is a dark purple or dirty green, owing generally to the presence of hornblende, as at Mousehole; but I believe occasionally of actynolite, as at Porth Just; or of chlorite, as at *Wheal Buller*.[2]

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[1] Prof. Sedgwick, Camb. Phil. Trans. i. p. 108, & Geo. Trans. N.S. iii. p. 484: and Dr. Boase, Cornwall Geo. Trans. iv. p. 242, and Treatise on Primary Geology, p. 338.

[2] Table lviii.

masses at *Cook's-kitchen*,[1] *Dolcoath*,[2] *Tincroft*,[3] *Wheal Buller*,[4] and Cligger-point, are in general of the ordinary texture; the large bed, under somewhat similar circumstances at *Wheal Vor*,[5] is, however, quartzose, and one of those at *Cook's-kitchen*[1] is rather fine grained.

The veins of granite in the slate, which occur underground in *Botallack*,[6] *Wheal Edward*,[7] *Providence Mines*,[8] *Wheal Buller*,[4] *Cook's-kitchen*,[1] *Dolcoath*,[2] *Tincroft*,[3] *Wheal Vor*,[5] and *Wheal Trannack*,[9] are, for the most part, in the neighbourhood of the *lodes*, by which they are usually cut off, and on the opposite sides of which they do not correspond. At *Wheal Vor*,[5] the bed of granite which traverses the slate, and the veins striking from it towards the main body of the granite, appear only on one side of the *lode*, and these small strings exhibit the phenomena of *heaves* and *throws*. At *Providence Mines*,[8] although there are veins of granite on both sides of the *lode*, their sizes and positions would in no respect correspond, if they could be brought in contact. In the same mine, and also in *Cook's-kitchen*,[1] the joints traverse both slate rocks and granite veins, and cut off, and apparently terminate some of the latter. In *Wheal Edward*,[7] the veins appear only on one side of the *lode*, and in *Botallack*,[6] a granite vein accompanies the *lode* for some distance into the slate. At *Tincroft*,[3] of three granite veins intersected by a *cross-course*, two

[1] Table li. [2] Table l. [3] Table lii. [4] Table lviii. [5] Table xlv. [6] Table vii. [7] Table v. [8] Table xxi. [9] Table xlvi.

of them, and a thin body of slate between them, are *heaved;* whilst the third vein, which is simply intersected, does not appear at the surface, but is first seen at 25 fathoms deep.

At *Providence Mines,*[1] the granite veins seem to correspond with the cleavage of the slate, but such a coincidence is unusual.

The granite veins are usually larger, and extend further from the parent rock into the hornblende rocks, and into the purple slates, than they do in any other varieties of the slate formation; and they are mostly smallest in the schistose rocks. But no general rule seems applicable to the bearings, dips, and compositions of the granite veins, than which nothing can be, in all respects, more irregular.

THE SLATE FORMATION,

Rests on the granite at an angle which on the whole varies but little from 45°, there are, however, some exceptions. Thus, at *Great-work,*[2] the angle is 70-80°, and the inclination is even reversed for a short distance, so that the granite rests on the slate: the interlying beds of granite and slate which occur at *Dolcoath,*[3] *Cook's-kitchen,*[4] *Tincroft,*[5] *Wheal Buller,*[6] and Cligger-point,[7] and the veins of granite which traverse the slate in these, and in many other cases, have been already described.[8]

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[1] Table xxi. [2] *Ante,* p. 50, & Table xliii. [3] Table l. [4] Table li. [5] Table lii. [6] Table lviii. [7] *Ante,* p. 96. [8] Ibid, p. 14.

I have previously mentioned the association of schorl with felspar, and with quartz: these often graduate into varieties of felspar rocks, which are sometimes, indeed, almost wholly felspar, but in them more commonly that mineral is mixed with hornblende, or, occasionally, with chlorite, and now and then it alternates with a mixture of schorl and quartz.

It is by no means easy to describe the mineralogical composition of these rocks with accuracy, as the proportions of their various constituents are perpetually varying, even whilst their other general relations remain the same: indeed, there is no district of any considerable extent where the elements do not vary in character, as well as in proportion. Thus, the greenstones by shades pass into actynolite and axinite rocks: with these chlorite is very commonly mixed, and near the granite mica and talc are also often associated; whilst schorl, or some similar mineral, appears in a very irregular manner, giving the whole a most complicated character. It may, however, be stated, that felspar, schorl, hornblende, chlorite, and mica, are the prevailing components; and their mixtures are sometimes compact, and at others schistose.

The schorl-rocks of the slate series are most prevalent in the districts where tin ores abound: as at *Wheal Vor*,[1] *Poldory*,[2] and near Saint Blazey.[3]

In general the alternating bands of quartz and felspar, and of schorl and quartz, are perfectly

[1] Table xlv. [2] Table lxi. [3] *Ante*, p. 130, note.

distinct, but in thickness they vary extensively, being sometimes very broad, and at others as thin as a sheet of paper. This lamination is capriciously curved, and exhibits most extraordinary contortions, which are again, not uncommonly, cut through and *heaved* or displaced by other eccentric, but similar, layers.

The structure of the slate near the granite is in general compact, but in this respect, as also in the composition, it varies in different districts. Thus, in the Saint Just,[1] Saint Ives,[2] and Tavistock[3] districts, the felspar is mixed with hornblende, and a regular and undoubted greenstone prevails, and actynolite, axinite, and garnet, are not uncommon. These minerals are frequently found in distinct veins, but they are more generally mixed with felspar; but even then the character of a vein very often occurs, producing the short irregular strings of actynolite, axinite, and garnet rock, as may happen, which are so common in the greenstones at the Narrow-point,[1] Wheal Cock Cairn,[1] Lariggan-rocks,[4] and the Greebe-rock near Marazion.[4]

These assume various tints of green, purple, violet, and brown, depending on the nature and proportion of the mineral mixed with the felspar:[5] and the veins often contain *vughs* lined with crystals.

These hornblende rocks sometimes occur at a distance from the granite: as, for example, in *East*

[1] *Ante*, p. 7. [2] Ibid, p. 18. [3] Ibid p. 136. [4] Ibid, p. 28.

[5] "Some of the compact kinds of this genus are very beautiful, having a "light violet-coloured basis, which is variegated with stripes, and marbled "markings of the dark blue species."

DR. BOASE, *Treatise on Primary Geology*, p. 44.

Wheal Crofty,[1] *North Roskear*,[1] *Trevaskus*,[2] and in various parts of the Saint Austell[3] and Tavistock[4] districts.

Near Mousehole,[5] and at Breage,[6] Crowan,[7] and Camborne,[8] occurs a brownish purple rock, often variegated, apparently composed of felspar, with hornblende, chlorite, and perhaps other analogous minerals, as well as a little mica arranged in the ill-defined planes, which have only a very obscure, imperfect, and partial cleavage,[9] so that, as a whole, this rock may be considered compact.[10]

Where chlorite is mixed with felspar, forming the slate rocks near their junction with the granite, the structure is generally thick and lamellar; and in such cases the felspar is frequently decomposed: as

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1 *Ante*, p. 61. "In driving an adit towards a mine, the Old Pool, I believe, "it has often been told me, that it (the rock) was so remarkably compact in one "place as immediately to turn the point or edge of every tool, so that it was "found impossible to drive the hole deep enough to employ the blast by gun-"powder: the miner was compelled little by little to pick through that part of "it, in doing which the seat-board was not once moved forward during the space "of 12 months." MR. WM. PHILLIPS, *Geo. Trans.* o.s. ii. p. 133.

2 *Ante*, p. 36. 3 Ibid, p. 125. 4 Ibid, p. 136. 5 Ibid, p. 27 6 Ibid, p. 51. 7 Ibid, p. 36. 8 Ibid, p. 62.

9 "The rock, in question, exhibits various shades of dark blue and purple, "sometimes of an uniform colour, but occasionally with dark spots or patches "on a light blue basis;—it varies from hard to very hard, and breaks, though "not easily, into thick plates full of joints; its surface is often spangled with "a micaceous looking mineral, the parallel arrangement of which imparts to "the mass a laminated structure."

DR. BOASE, *Cornwall Geo. Trans.* iv. p. 390.

10 "*Inferior Slate.* At and near its immediate contact with the granite "appears as a somewhat indistinct and ill-characterized gneiss, in some beds of "which the felspar so far predominates that they have been termed *slaty felspar*. "* * * The brownish purple colour by which it is almost everywhere dis-"tinguishable, its very limited extent, and its gradual passage into the common "killas, have been sufficiently noticed by most recent observers."

REV. J. J. CONYBEARE, *Annals of Philosophy*, vi. (1823) pp. 35–6.

at *Wheal Buller*,[1] *Wheal Unity Wood*,[2] and *Fowey Consols*.[3]

Sometimes, though rarely, a schistose rock may be seen in the vicinity of the granite: as at Cligger-point,[4] *Wheal Coates*,[5] and Kit Hill.[6] In these cases it is micaceous, and, in the first, consists of felspar and white mica, with some traces of laminated schorl and quartz; and, in the other two, of a micaceous felspar rock, which abounds in iron and turns red on decomposition, and contains patches which have plenty of schorl.

Whatever rocks may be in the immediate vicinity of the granite, whether greenstones, purple felspar-slates (*cornubianite*[7] and *proteolite*[8]), schorl rocks, micaceous, chloritic, or clay-slates, still, at a greater distance from it, a schistose clay-slate generally succeeds. This has a different aspect in those districts where the *lodes* contain tin ores, from that which it takes in others where they are most productive of copper ore. In the former it is usually a bluish-green with occasional thin white layers,—yet, sometimes it is brick-red; and, though schistose, the structure is foliated and apparently micaceous with a greasy appearance, whilst its cleavage is often very uneven: as at *Wheal Vor*,[9] *Polberrow*,[10] *Wheal Kitty*,[11] *Polgooth*,[12] *Drake Walls*,[13] &c. Where copper

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1 Table lviii. 2 Table lxvi. 3 Table lxxxix. 4 *Ante*, p. 96. 5 Ibid, p. 100. 6 Ibid, p. 134.

7 Dr. Boase, Cornwall Geo. Trans. iv. p. 390. 8 Ibid, p. 394.

9 *Ante*, p. 51. 10 Ibid, p. 101. 11 Ibid, p. 101. 12 Ibid, p. 125. 13 Ibid, p. 135.

ores are found in the schistose slates, they are, on the contrary, generally rather soft, of an homogeneous texture, silky lustre, and rather thickly lamellar structure. The prevailing hues vary from a full blue to pale fawn-colour, or yellowish-white: as at *Wheal Darlington*,[1] *Binner Downs*,[2] *United*[3] *and Consolidated*[4] *Mines, Wheal Leisure and Great Saint George*,[5] *Pembroke*,[6] *East Crennis*,[7] *Fowey Consols*,[8] *Wheal Franco*,[9] *Wheal Friendship*,[10] &c. In many cases, however, the colours are red, brown, or very dark blue: as at *Ting Tang*,[11] in several parts of Saint Agnes,[12] *Pembroke*,[6] and *Wheal Friendship*.[10] Sometimes, but not often, the cleavage is curved and contorted, and though a thin-bedded purple slate occurs near Tavistock,[13] it is seldom very schistose in the metalliferous districts.[14]

Throughout the whole of the slate series, quartz prevails in beds, veins, in irregular and unconnected masses, and also diffused through the rocks: many of these contain the ores both of tin and copper, of the former at *Polberrow*[15] and *Drake Walls*,[16] and of the latter at *Binner Downs*,[2] *Wheal Fortune* in Breage, *Wheal Music*,[17] *Wheal Leisure*,[5] *Pembroke*,[6] &c.

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1 Table xxiv. 2 Table xxxix. 3 Table lxi. 4 Tables lxii. and lxiii.
5 *Ante*, p. 102. 6 Ibid, p. 125. 7 Ibid, p. 125. 8 Ibid, p. 125.
9 Ibid, p. 135. 10 Ibid, p. 135. 11 Table lx. 12 *Ante*, p. 101. 13 Ibid, p. 135.
14 "It would be almost impossible to convey by words the precise character "of the slate which the miner prefers for copper, though it is one which the eye "readily seizes after a little practice. That which he prefers for tin has a "different aspect, being generally more dull in appearance, darker coloured, "harder, and more resembling altered slate, which, in fact, it frequently seems "to be." Mr. De la Beche, *Report*, p. 336.
15 *Ante*, p. 101. 16 Ibid, p. 135. 17 Ibid, p. 98.

These small metalliferous strings are, as already stated, in every respect similar to those of tin ore in granite at *Balleswidden*,[1] *Carclaze*,[2] and the *Bunny*.[3]

At *Herland*,[4] large quantities of round masses of granite of various sizes are completely enclosed and imbedded in the slate, and neither fissures, veins, nor indeed any channels of communication subsist between them and the *lodes* or rocks. This is the more remarkable as it occurs not less than three or four miles from the nearest indication of granite at the surface.

Somewhat similar unconnected globular masses of granite occur at 49 fathoms deep in *Wheal Buller*.[5]

Spheroidal masses of slate and of quartz occur in like manner in the slate at *Relistian*;[6] and a somewhat similar concretionary structure prevails near the *lodes* in *Duffield*[7] and *Trevaskus*,[8] but, in the former of these, some of the nodules are of *elvan*, of which a *course* runs within a short distance. The granite vein in *Tincroft*,[9] which does not appear at the surface, may perhaps be classed with these concretions.

In 1829 I had detected the remains of various *corallines*, &c., in the thin-bedded calcareous slates of Lower Saint Columb Porth, and I have subsequently also found *encrinal* stems; these, and other organic remains at Newquay[10] which had escaped my

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1 *Ante*, p. 15. 2 Ibid, p. 120. 3 Ibid, p. 121. 4 Ibid, p. 36, & Table xxxiv. 5 Table lviii. 6 Table xxxvi. 7 Table xxxvii. 8 Table xxxiv. 9 Table lii.

10 Among others I have been shewn what I believe to be remains of *turbinolia*.

notice, have been more recently discovered by Mr. De la Beche.[1] At Porth Island, and at Trevelgue Common, there are some considerable beds of limestone which have been worked for economic purposes,[2] but as little care was paid to its burning, it was sometimes fused, and its use was abandoned.

The occurrence of organic remains in the slates of the Saint Austell district has been already mentioned.[3]

The thick-flaggy beds of sandstone which occur at Black Down and Heathfield, near Tavistock,[4] probably belong to a different series of rocks. In the same neighbourhood, Mr. De la Beche supposes that the culm-measures thin out towards the south.[5]

The planes of slaty cleavage almost universally dip from the granite, and the various layers of slate thus irregularly mantle round the flanks of the granite hills. The dip of their lamination is seldom so rapid as that of the line of junction with the granitic mass beneath, as it is seldom more than 30°, and is mostly less than 20°, whilst that of the granite usually exceeds 40°.[6] This dip seldom, however, continues the same for considerable distances, and is even reversed within small tracts; owing, perhaps,

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[1] Report, p. 86. [2] Cornwall Geo. Trans. iv. p. 261.

[3] *Ante*, p. 125. I am inclined to think there is a great resemblance between the organic remains at Lower Saint Columb Porth, Newquay, &c., on the north coast, and those of Apple Tree and Crennis beaches, Par, Polkerris, &c., on the south.

[4] *Ante*, p. 137. [5] Report, p. 109.

[6] Were the laminæ of the slates laid horizontally, though they would thereby cover a larger space than at present, they would not fill the area now occupied by the granite. No troughs in any of our granitic ranges contain unconnected patches of slate within them.

to the irregular thickness of the laminæ in different places, as there is little or no appearance that they have undergone mechanical displacement.[1]

The alterations in the characters of the slate rocks appear to take place at right angles to the strike of their cleavage; and hence the succession of their laminæ must indicate, if anything can do so, the successive periods of their deposit.

The slate-rocks of every kind[2] are traversed by joints or planes of structure,[3] which intersect them, the adjoining granite, and all other rocks and veins, equally without interruption, and divide all into angular masses. The general configuration which results is a sort of rhomboidal form, but a third series of planes often intersects these diagonally, and converts them into triangular blocks. In another part of this Paper I intend to recapitulate the directions and other characters of the joints; for the present it may therefore suffice to say, that though they have often considerable regularity of bearing, they are frequently curved.

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1 The fossiliferous rocks at Apple Tree and Crennis beaches, and at Par, are within two miles of the granite; they preserve a perfectly regular bearing for several miles, and are nowise deflected or forced out of their line of strike by the granite: on the contrary, the beds rather appear to curve slightly towards it.

2 The term *Killas* is locally applied to every member of the slate series; and, in fact, to every rock which our miners cannot identify as either granite or *elvan*. It is therefore evident that this name is applied to rocks of very different characters: as, for example, to the hornblende slates and greenstones of Saint Just and Saint Ives, as well as to the clay slates of Gwennap, Saint Agnes, and Saint Austell. The Saint Just and Saint Ives *killas* would generally be known in the other districts by the designation of *iron* or *ire-stone*.

3 Provincially called *queres*.

THE ELVANS.

As much confusion has resulted from the uncertain and contradictory employment of this term, it seems desirable to point out its application in this Paper.

By *Elvan* I intend a rock possessing the same constituents as granite; which, as in that rock, vary in their number and proportions, of which the structure is always porphyritic. It is always a subordinate rock, passing indifferently through all others in the metalliferous districts, and may be denominated a vein or dyke according to its size, which is extremely variable.

Some *elvans*, as at *United Mines*,[1] and *Polgooth*,[2] are but a few feet, but in general they are several fathoms wide: and in this respect the same *elvan* is subject to very great changes throughout its course; as at *Wheal Buller*[3] and *Wheal Budnick*.[4]

Their directions are in general between E. and W., and N.E and S.W., the average is perhaps about 20° S. of W. There are however a few which have a very different bearing; as at Pra-sand,[5] *Parbola*,[6] Ligger-bay,[7] *Cardrew Downs*,[8] *United Mines*,[1] and Clizey-hill,[9] all of which strike several degrees to the northward of west.

Their dips are generally less than those of the *lodes*, and may average from 40 to 60°; and many more of them incline towards the north, than to the south.

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[1] Table LXI. [2] Table LXXXV. [3] Table LVIII. [4] Table LXXXIII. [5] *Ante*, p. 51. [6] Ibid, p. 38. [7] Ibid, p. 105. [8] Table LXVIII. [9] *Ante*, p. 126.

Both in direction and dip they suffer many flexures; as at Porth Just,[1] Mousehole,[2] Penzance Battery-rocks,[3] Swan-pool,[4] Pulla,[5] *Roskear*,[6] *Cairn Brea*,[7] *Ting Tang*,[8] White Works,[9] Creeg-quarry,[10] Kerley-barrow,[11] Saint Agnes,[12] Penhale,[13] *Watergate-bay*,[14] Clizey-hill,[15] Grenofen,[16] and Morwell Down,[17] in all of which localities, and in many more, they appear at the surface: in the first four on their lines of bearing, and in all the others on the direction of the dip also.

The *elvan-courses* traverse granite and slate alike without interruption; and their character varies with that of the rocks through which they pass. When in slate they generally consist of a compact basis of felspar and quartz, often containing schorl, and sometimes a little felspar, and enclosing porphyritic crystals of the latter, which have frequently a buff, pink, or dove, and now and then a deep crimson colour: double-pointed crystals of translucent quartz, having a kind of vitreous lustre, are also very common. In granite they are generally of the same materials but different in proportions, and also

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1 Dr. Boase, Primary Geology, pp. 173-178. 2 Ibid, p. 173.
3 Ibid, p. 51: *ante*, p. 30.
4 *Ante*, p. 91: Dr. Boase, Cornwall Geo. Trans. iv. p. 315: & Mr. Thomas, Mining Review, No. viii. (June, 1836), p. 275.
5 Mr. Thomas, Ibid, p. 275.
6 Professor Sedgwick, Cambridge Phil. Trans. i. p. 129: *ante*, p. 62.
7 *Ante*, p. 63. 8 Table ix. & *ante*, p. 85*. 9 *Ante*, p. 84. 10 Ibid, p. 82.
11 Ibid, p. 82.
12 Rev. J. J. Conybeare, Geo. Trans. iv. p. 401: *ante*, p. 103. 13 *Ante*, p. 105.
14 My own notes, quoted by Dr. Boase, Cornwall Geo. Trans. iv. p. 261. Mr. De la Beche, Report, p. 179.
15 *Ante*, p. 126. 16 Ibid, p. 137. 17 Ibid, p. 137.

differently aggregated: here felspar and mica seem to be the prevailing minerals, which are often mixed with some schorl; whilst the double-pointed crystals of quartz and porphyritic crystals of felspar still abound, and the rock is finer grained.

Their general aspect is however very dissimilar; as when they are in granite they resemble that rock much more closely than they do when they are in slate. This difference in the appearance of the *elvan* is not easily described, but nevertheless it may readily be detected by the eye. It may be well seen in an *elvan*, one of those also seen in *Dolcoath*,[1] in granite near Camborne workhouse: in another which occurs at 68 fathoms deep in the granite of *Cook's-kitchen*[2] (*g*): in those which are so largely quarried in the granite on the south of *Wheal Buller*,[3] and which may be advantageously compared with those in the slate at *Wheal Beauchamp*[3] (*a*): and, again, at *The Elvans* (an abandoned mine), near *Penstruthal*: the last are continuations in the granite of the *elvan-courses* at Pulla,[4] and Tresamble, and which may be traced still further eastward in Carnon-valley. In all these their character, in granite, differs most remarkably from that which the same *courses* exhibit in slate.

Again, there is also a very considerable difference in the same *elvans* when they pass through the various members of the slate series; for example, that in the greenstone, actynolite and axinite rocks

[1] Table l. & *ante*, p. 63. [2] Table li. & *ante*, p. 63. [3] Table lviii. & *ante*, p. 81.
[4] Mr. Thomas, Mining Review, No. viii. (June, 1836), p. 275.

between Penzance Pier[1] and the *Wherry Mine*,[2] is widely different from any which occur in the schistose (clay) slates of *Wheal Darlington*,[3] the *Marazion Mines*,[4] *Gwallon*,[5] and *Great Wheal Fortune*.[6] The *Wherry Mine elvan*[7] cannot, indeed, be traced with certainty far eastward, but no doubt is entertained that it is one of those in the mines already mentioned.

A difference in the aggregation of the various minerals is not unfrequent in different places, and the *elvan*, though equally crystalline, is sometimes finer grained on the outside, whilst in the centre it is coarser and more decidedly porphyritic in character: but this difference is, in general, more marked in those which traverse the crystalline slates, than in others which intersect the schistose and more homogeneous members of the same series. The distinction here pointed out will become very evident on a comparison of the *elvan* at Pra-sand[7] with those at the mines near Marazion, or with the *Wheal Vor elvans*,[8] all which are in the same neighbourhood; or of those which occur in the greenstone at *East Wheal Crofty*,[9] with the *elvans* of Skues,[10] or *Wheal Beauchamp*,[11] which are in lamellar (clay) slates, and not far apart.

A spheroidal structure is common among the *elvans*, and large portions, which have no other distinguishable difference, often take this form and are separated from the surrounding parts of the same

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[1] *Ante*, p. 25. [2] Ibid. p. 51. [3] Ibid. p. 61. & Table xxxv. [4] Table xxxi. [5] Table xxix. [6] *Ante*, p. 61. [7] Ibid. p. 62. & Table xli. [8] *Ante*, p. 61. & Table lvi. [9] *Ante*, p. 87. [10] Ibid. p. 84. & Table lvii.

rock by concentric bands of a ferruginous mineral, often decomposed into a sort of clay, as at Pulla,[1] whence some fine specimens have been obtained, and at the *terminus* of the Hayle-railway at Redruth.[2] In these globular concretions, however, there is frequently a difference in composition, resulting from the presence of schorl, the mineral which also prevails in the similar aggregations which occur in the granite, and give it a slight resemblance to the orbicular granite of Corsica.[3]

Innumerable joints traverse the *elvans* in all directions, dividing them into small irregularly shaped blocks. In some of the harder and more quartzose varieties these joints are often coated with a ferruginous crust; and in the softer ones, having yielded to decomposition, they are filled with felspar clay, and at *Wheal Buller*[4] they also contain thin plates of native copper.

Plumbago (carburet of iron) has been found in small isolated masses in the *elvans* at *Wheal Wellington*[5] and Restronguet;[6] and copper pyrites, under similar circumstances, at *Wheal Buller*.[4]

Beside their ordinary components which have been described, some *elvan-courses* have been largely worked in different places for the metallic minerals which they contain, and which may, perhaps not improperly, be termed accidental constituents. Thus at the *Wherry Mine*,[7] *Parbola*,[8] *Relistian*,[9] *Wheal*

[1] Mr. Thomas, Mining Review, No. viii. (June, 1836), p. 275.
[2] *Ante*, p. 80. [3] Dr. Boase, Prim. Geol. p. 114. [4] Table lviii. & *ante*, p. 81.
[5] *Ante*, p. 61. [6] Mr. R. W. Fox, in Mr. De la Beche's Report, p. 162.
[7] *Ante*, p. 31. [8] Ibid, p. 38. [9] Ibid, p. 38, & Table xxxvi.

Vor,[1] *The Elvans, Wheal Unity Wood*,[2] White-works,[3] *Bissoe-bridge Mine*,[4] *Wheal Coates*,[5] *Polberrow*,[6] and *Polgooth*,[7] (and perhaps also at *Wheal Budnick*,[8]) the body of the *elvan* has been removed for the tin ore with which it abounds.[9]

The mode in which metallic minerals are thus disposed in the *elvan-courses* is not always the same: at the *Wherry Mine*[10] the tin ore seems to be in beds; at *Parbola*,[11] and *Polgooth*,[7] in small irregular veins; whilst in *Wheal Coates*[5] it was often as a silicate of tin, which assumed the form of felspar crystals.[12] At *Wheal Vor*,[1] White-works,[3] and *Polberrow*,[6] irregular and unconnected masses of tin ore were distributed through the *elvan*, and in all the other instances the whole mass of *elvan* seemed to be penetrated by it, as is sometimes the case in other rocks.[13] A thick-bedded schistose structure sometimes appears in the *elvan* which is in immediate contact with the slate, as at Pulla,[14] and Kerley-barrow,[15] but this is rare.

It is not usual for the strike and dip of *elvan-courses* to run parallel with those of the laminæ of the schistose rocks; this coincidence, however, occurs at *Herland*,[16] where several *elvans* preserve such a parallelism. The *walls* of *elvan-courses* are usually far more regular and even than those of the *lodes*;

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1 *Ante*, p. 53, & Table xlv. 2 *Ante*, p. 82, & Table lxvi. 3 *Ante*, p. 84.
4 Ibid, p. 85*. 5 Ibid, p. 100. 6 Ibid, p. 104. 7 Ibid, p. 126, & Table lxxv.
8 Table lxxxiii. 9 M. Fournet, Etudes sur les Dépots, Métallifères, p. 182.
10 *Ante*, p. 31. 11 Ibid, p. 38. 12 Mr. S. Davey, Cornwall Geo. Trans. iv. p. 484.
13 *Ante*, pp. 15–53–72–101–120–132–135.
14 Mr. Thomas, Mining Review, No. viii. (June, 1836), p. 275.
15 *Ante*, p. 85*. 16 Table xxxiv. & *ante*, p. 39.

one great cause for this seems to be that their directions often coincide with those of the joints in the rocks; a conformity which is very evident in the *cutting* at Clizey-hill,[1] and in the cliffs at Penhale.[2]

Veins often strike off from them into the contiguous rocks, of which there are good examples at *Wheal Buller*,[3] the *Consolidated Mines*,[4] Penhale,[2] *Wheal Budnick*,[5] and *Polgooth*;[6] but they are neither so frequent, nor apparently so extensive, as when they proceed from *lodes*.

In many cases, as at the *Consolidated Mines*,[4] *Wheal Budnick*,[5] and Saint Agnes,[7] the *elvans* contain large imbedded masses of slate, the edges and angles of which are often well defined and sharp. It has also been supposed that in some places there are large detached masses enveloped in the slate, as at the *Consolidated Mines;* such instances, however, are rare, and the intelligent observers[8] who quote them do so with hesitation. I have myself seen no such large masses so situated as to leave no uncertainty respecting them; but I have often noticed smaller separate lumps of *elvan*, as in the slate near Cairn Brea,[9] in the *Badger-lode* at *Herland*,[10] and in *Relistian*.[11] In the latter case these globular

[1] *Ante*, p. 126. [2] Ibid, p. 105. [3] Ibid, p. 81, & Table lviii. [4] Table lxii. [5] Table, lxxxiii. [6] Table lxxxv. & *ante*, p. 126.

[7] The Rev. J. J. Conybeare, Geo. Trans. iv. p. 401: *ante*, p. 104: and a Paper of my own, in the Report of the Royal Institution of Cornwall (1838), p. 38.

[8] Mr. Thomas, Report, p. 17: Mr. Carne, Cornwall Geo. Trans. ii. p. 82: and Mr. Burr, Mining Review, No. vii. (July, 1835), p. 28, and Practical Geology, p. 287. [9] *Ante*, p. 86.

[10] My Lecture on Metalliferous Deposits, Edinburgh New Phil. Journal (Oct. 1836), xxii. p. 166: Table xxxiv. and *ante*, p. 40.

[11] Table xxxvi. & *ante*, p. 40.

masses of *elvan* were sometimes enclosed in the *lode*, sometimes in the *country*, but still more frequently in an interposed layer of rock forming a kind of transition between them.[1] In all these localities, however, similar shaped pieces of slate were far more numerous than those of *elvan*.

At *East Wheal Crofty*,[2] *Wheal Wellington*,[3] &c., *elvan-courses* traverse the greenstones; this also happens at Penzance Battery-rocks,[4] and at Porth Just;[5] but in general they are far more numerous in the other rocks of the metalliferous districts than they are in the greenstones, and the granites with which they are associated. Indeed, in the whole of the extensive formation of these rocks in the Saint Just[6] and Saint Ives[7] districts, that at Porth Just[5] is the only *elvan* observed in the slate, and the only trace of that rock in the granite is at Carreg-looz.[8]

The difference between their structure and mineral composition renders the *elvan-courses* very conspicuous whilst traversing the slate, and their general coincidence with one series of the divisional planes of these rocks, by giving them well-defined *walls*, produces a still stronger contrast between them. On the other hand, though bounded by the same joints whilst they traverse the granite, from the similarity of their ingredients they more rarely attract attention. But, notwithstanding their apparent

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[1] Mr. Carne, Phil. Trans. (1807), p. 293, Cornwall Geo. Trans. ii. pp. 61–94: *ante*, p. 40.

[2] *Ante*, p. 62, & Table lvi. [3] *Ante*, p. 61. [4] Ibid, p. 30.

[5] Dr. Boase, Primary Geology, pp. 173–178.

[6] *Ante*, p. 7. [7] Ibid, p. 16. [8] Near Porth Just, in Saint Just.

changes in mineral character, their ultimate analysis, as well as that of both these rocks, may not be found to differ very materially.[1]

As the

SYMMETRICAL OR JOINTED STRUCTURE OF ROCKS

Presents lines of little or no resistance, and thus affords very great facilities to the operations of the miner, he has noticed and made use of it time out of mind.

Some joints traverse all the rocks, as well as the *lodes* and *cross-courses*, without interruption; and some coincide with the directions of the *elvan-courses:* some with those of the *lodes*, and others with those of the *cross-courses;* certain of them, again, seem to be confined to one kind of rock or another, and a few appear not to extend beyond the *veins*.

Their existence has been long recognized by Geologists; they are mentioned even by Mr. Pryce.[2] It seems, however, to have been reserved for more modern times to point out the coincidence of some of them with the *veins*, and to establish the fact

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[1] "If that, which I cannot but suspect to obtain as a general law; namely, "that stratified *rocks are in their mineralogical composition only varieties of the "crystalline masses with which they are most largely and closely associated*, be "admitted, we shall have (no) difficulty in recognizing in the numerous elvans "by which it is traversed, the crystalline *analogue* of the killas."

REV. J. J. CONYBEARE, *Annals of Philosophy*, vi. (July, 1823), p. 37.

[2] Mineralogia Cornubiensis, p. 23.

of their uniformity for considerable distances. Dr. Berger,[1] Dr. Macculloch,[2] and Professor Sedgwick,[3] among recent observers, first treated of the subject: but Dr. Boase,[4] and Professor Phillips,[5] appear to have first pointed out the great extent to which the jointed structure affects the condition of rocks and *veins*. Mr. Enys,[6] Mr. R. W. Fox,[7] Mr. Hopkins,[8] Mr. De la Beche,[9] and others,[10] have also devoted some attention to the subject.

The natural developement of the joints is almost wholly produced by the decomposition which takes place more readily in their direction than elsewhere. On this account it is often very difficult, if not impossible, to determine which is the principal series; because their exposure to degrading causes in one direction more than another will occasion the appearance of one set of joints in one place, whilst, in another, a similar cause may operate in a different direction and bring out another system of lines.

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1 Geo. Trans. o.s. i. pp. 115–150.

2 Geo. Trans. o.s. ii. pp. 67–71–74: System of Geology, ii. pp. 94–187.

3 Cambridge Phil. Trans. i. p. 108: Address to the Geological Society (1831): Phil. Mag. & Annals (1832), ix. p. 284: & Geo. Trans. N.S. iii. p. 469. Pl. xlvii.

4 Cornwall Geo. Trans. iv. p. 428: Proceedings of the British Association (1832), i. p. 579: Treatise on Primary Geology, p. 92: and London & Edin. Phil. Mag. (1835), vii. pp. 376–445, (1836), ix. p. 4, (1837), x. p. 14.

5 Geo. Trans. N.S. iii. pp. 4–17: Proceedings Brit. Assoc. (1834), iii. p. 655: Illustrations of the Geology of Yorkshire, Pt. ii. pp. 90–98: Ency. Metrop. (Mixed Sciences, iv.), Art. *Geology*, p. 543: *Geology*, re-printed from Ency. Brit., p. 107: & Lardner's Cabinet Cyclo. (No. 97), *Geology*, i. p. 65, fig. 25.

6 Lond. & Edin. Phil. Mag. (1833), ii. p. 322. 7 Ibid, p. 326

8 Camb. Phil. Trans. vi. p. 78: Lond. & Edin. Phil. Mag. (1836), ix. pp. 171–366.

9 Researches in Theoretical Geology, p. 103: Report, p. 270.

10 My own Paper on Metalliferous Veins, Edin. New Phil. Journal (1837), xxii. p. 159.

Hence, within a very short distance, the principal joints may seem to run at nearly right angles to each other.

This, indeed, is somewhat the case in general, for two great systems of joints intersect nearly at right angles, dividing the rocks into quadrangular masses; and, as they are more frequently highly inclined than vertical, the symmetrical forms are more commonly rhombic than cubical.

But, beside these joints which approach to rectangularity, there are also others which have an intermediate direction, and divide the blocks diagonally into triangular masses, which in some situations seem to be rather more evident than the rhombs.

But, though the joints often preserve a tolerable regularity for some distance, they have frequent and considerable flexures, on the lines both of direction and of dip; the opposite bounding planes of the jointed masses are therefore seldom quite parallel. Often, too, the diagonal joints seem to unite with one of the others; and, not uncommonly, by a considerable curvature one of the rectangular joints swerves from its course, and continues for some distance as a diagonal one. Still, on the whole, there are two series of divisional planes which are permanent, whilst the third is perhaps less constant: *Table* xcix. gives a general view of their directions in the different mining districts.

But the granite and the *elvans* sometimes also exhibit a sort of horizontal *bedding*, which is, except in thickness, not altogether unlike the schistose

Table XCIX.

GRANITE.

Districts.	N. to 10° W. of N.	10-20° —	20-30° —	30-40° —	40-50° —	50-60° —	60-70° —	70-80° —	80° W. of N. to W.	W. to 10° S. of W.	10-20° —	20-30° —	30-40° —	40-50° —	50-60° —	60-70° —	70-80° —	80° S. of W. to S.
Saint Just.....	..	..	3	..	1	..	..	..	1	..	..	..	..	..	..	..	..	1
Saint Ives.....	..	..	1	1	3	..	3	..	..	1	..	3	1	..	..	..	..	..
Marazion	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gwinear, &c. ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Helston	1	1	..	1	2	..	..	..	..	..	1	1	1	..	..	1	..	..
Camborne, &c. .	2	1	..	..	2	..	..	..	..	..	1	..	..	1	..	..	..	..
Redruth, &c. ..	2	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..
Saint Agnes ...	1	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Saint Austell ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tavistock, &c. .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
									SLATE.									
Saint Just.....	..	..	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..
Saint Ives.....	2	..	..	..	2	..	..	..	..	..	1	..	..	1	..	..	..	..
Marazion	12	..	..	..	4	..	1	..	5	..	1	..	..	4	..	1	..	..
Gwinear, &c. ..	2	2	3	..	8	2	..	1	..	1	4	..	1	2	..	..	..	..
Helston	2	1	..	1	1	..	..	..	..	..	1	1	..	2	..	2	..	..
Camborne, &c. .	3	2	..	1	6	..	..	..	..	..	..	1	..	2	..	..	..	..
Redruth, &c. ..	5	1	..	..	3	..	..	..	1	..	2	2	2	3	..	..	..	..
Saint Agnes ...	8	1	..	..	4	..	..	1	4	..	2	4	..	1	..	..	..	..
Saint Austell ..	5	..	..	..	2	..	..	..	2	..	1	..	..	1	..	2	..	..
Tavistock, &c. .	3	..	..	..	..	..	..	1	5	..	1	..	..	..	..	..	..	..
									ELVAN.									
Saint Just.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Saint Agnes ...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Marazion	1	..	..	..	3	..	..	..	..	..	..	..	..	1	..	1	..	..
Gwinear, &c. ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Helston	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Camborne, &c. .	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Redruth, &c. ..	1	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..
Saint Agnes ...	..	..	..	..	2	..	..	1	..	..	..	..	..	1	..	..	..	..
Saint Austell ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tavistock, &c. .	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total....	51	11	7	4	44	2	4	4	19	2	16	17	5	19	0	7	0	1

structure of some of the slates already described, of which it may not improbably be a modification.[1]

The horizontal as well as the vertical joints are, in different places, at very different distances from each other; in some cases several feet, and in others only a few inches. The intersections of these three series of divisional planes separating the rocks into quadrangular masses, expose their edges and angles to the influence of decomposing causes; and which, unquestionably, have produced the prismatic structure and the fanciful forms which many of our cliffs and cairns often assume; among which, particularly, may be instanced the spheroidal figure so commonly presented by the granite tors.[2]

Examples of this gneiss-like granite occur at the quarry-pits in Saint Just, at Tregoning-hill,[3] near the Half-way-house in Wendron, at the Cheese-wring, on Kit Hill[4] near Callington, and in many other places. A similar structure may be observed in the *elvans* at Pulla,[5] and Kerley-barrow:[6] indeed it is

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[1] Mr. R. W. Fox states that he has produced a laminar arrangement of clay by voltaic agency (Report of the Royal Cornwall Polytechnic Society, 1837, p. 68: Annals of Electricity, ii. p. 54: Edin. New Phil. Journal, xxv. p. 196: and Proceedings of the Geological Society, iii. p. 9). The experiment has, however, after repeated trials failed, both in Mr. Sturgeon's hands (Annals of Electricity, ii. pp. 395-475, & iii. pp. 329-423), and in my own (Annals of Electricity, iii. p. 339).

It is well known that a sort of lamellar structure obtains when the *slime* from *stamping* tin and copper ores is allowed to dry; and that a somewhat similar disposition takes place in *china-clay* (*Ante*, p. 118): but no electrical action was ever suspected in either of these cases.

Address to the Geol. Society, by the Rev. W. Whewell (1839): Proceedings of the Geol. Soc., iii. p. 95: and Lond. & Edin. Phil. Mag. (1839), xiv. p. 505.

[2] Dr. Macculloch, Geo. Trans. o.s. ii. p. 71.

[3] *Ante*, p. 45. [4] Ibid, p. 132, note.

[5] Mr. Thomas, Mining Review (May, 1836), No. viii. p. 275. [6] *Ante*, p. 82.

not rare even in the *lodes*, as at *Duffield*,[1] *Wheal Buller*,[2] &c.

But, beside the joints already described, and which may be considered in a certain degree normal, the *elvan-courses* are also often traversed by innumerable other planes which are short and irregular, and divide the whole of the rock into angular and unsightly blocks, rendering it unsuitable to any architectural purpose, and fit only for road-stones.

It will hereafter appear that the directions of the joints and of the *veins* sometimes coincide; this circumstance, however, does not affect the joints themselves, which are merely interruptions of continuity in the rock, and rarely present even the smallest opening. In the few instances to the contrary they are a few *lines* in breadth; they then contain clayey portions of the containing rocks, sometimes a little tin ore,[3] and now and then thin plates of native copper.[4] On the eastern side of Tregoning-hill[5] the faces of the joints in the granite are irregularly striated, like those of *slickensides* on the *walls* of many *lodes*.

The cliffs and beaches afford the most advantageous opportunities for studying this structure; but the few and isolated cairns of our higher grounds, and the quarries for obtaining building-stones, occasionally present instructive examples.

On the beach at Mousehole,[5] and Saint Michael's Mount,[5] many of the joints may be seen passing

[1] Table xxxvii. [2] Table lviii. [3] As at *Parbola*, *Polberrow*, and *Carclaze*.
[4] In *Wheal Mary*, and *Wheal Buller*. [5] *Ante*, p. 33.

uninterruptedly through both granite and slate, and through the veins of the former by which the latter is traversed. In the same localities may also be observed numerous other joints, which seem to be but short, and soon disappear: some of these are in granite, others in slate, and a few intersect both rocks.

Behind the pier at Penzance,[1] at the western side of Pra-sand,[2] in Creeg-quarry,[3] Trevellas Downs,[4] Penhale,[5] Clizey-hill,[6] and Grenofen,[7] the joints intersect both slate and the *elvan-courses*. In *Dolcoath*,[8] and *Cook's-kitchen*,[9] the same joints traverse the granite, slate, and *elvan-courses*. At *Trevidgia*,[10] *Tresavean*,[11] *Carleen (Wheal Vor)*,[12] and *Wheal Ann*,[13] both *lodes* and granite are cut through by the same joints; and the slate and *lodes* are equally crossed by similar ones in *Relistian*,[14] *Wheal Providence*,[15] *Charlestown*,[16] and many other mines.

In many instances, however, the joints are parallel to the *elvans*, as at *Gwallon*,[17] Clizey-hill,[6] &c. A similar coincidence between the joints and the *lodes* is also frequent, as at *Binner Downs*,[18] *Godolphin*,[19] *Wheal Vor*,[12] *Wheal Friendship*,[20] &c.; and between the former and the *cross-courses*, as at *Trevidgia*,[10] *Relistian*,[14] and *North Downs*.[21]

Whether the joints have originated in the contraction of the masses on cooling, from a crystalline

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[1] *Ante*, p. 30 [2] Ibid, p. 51. [3] Ibid, p. 82. [4] Ibid, p. 104. [5] Ibid, p. 105. [6] Ibid, p. 126. [7] Ibid, p. 137. [8] Table l. [9] Table li. [10] In Towednack, near Rosewall-hill. [11] Table lix. [12] Table xlv. [13] Table xlviii. [14] Table xxxvi. [15] Table xxxviii. [16] Table lxxxvi. [17] Table xxvi. [18] Table xxxix. [19] Table xlii [20] Table xcvi. [21] Table lxix.

arrangement of the particles on passing from a state of fluidity, or whether they are the consequences of some more recent convulsion, is a topic I shall not discuss, as it would lead to speculations which I have studiously avoided throughout this Memoir. Suffice it to say, that neither the schistose structure of the slates, nor the horizontal *bedding* in the granite and other compact and massive rocks, seems to influence the direction of the joints; which, I again repeat, traverse rocks, *veins*, and cleavage-planes, alike without interruption, and without distinction.

The characters and appearance of

THE METALLIFEROUS VEINS, OR LODES,

I shall consider under the following heads: viz., 1st, Composition and relations to the containing rocks;—2nd, Size;—3rd, Dip; and 4th, Direction.

I.—*On the composition of the lodes, and on their relations to the containing rocks.*

The *lodes* may be briefly described as quartzose portions of the rock, highly inclined, and of no great thickness, which are more or less mixed with metals and their ores. They have commonly one prevailing direction, subject to slight irregularities and curvatures as well in length as in depth, and traverse granite, slate, and the *elvans*, indiscriminately, and

almost always without other interruption than what may take place from their interferences with each other,[1] and with the *cross-courses, flucans,* and *slides.*

But, notwithstanding the workings of adjoining mines have often been extended for a considerable distance on *lodes* in the same directions,[2] it is not at all certain that the same *lode* has ever been traced for more than about a mile in length. In fact, they

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[1] Definitions of *lodes* have been given by Dr. Borlase, Nat. Hist., p. 143: M. Jars, Voyages Métallurgiques, iii. p. 192: Mr. Pryce, Mineral. Cornub., p. 79: Werner, New Theory of the Formation of Veins (Anderson's translation), p. 2: Dr. Berger, Geo. Trans. o.s. i. p. 158: Mr. Wm. Phillips, Ibid, ii. p. 126: Mr. Thomas, Report, p. 19: Professor Sedgwick, Camb. Phil. Trans., i. p. 108; Geo. Trans., iii. p. 483; Addresses to the Geol. Soc. (1831): Mr. Hawkins, Cornwall Geo. Trans., ii. p. 227: Mr. Carne, Ibid, ii. p. 51: Dr. Boase, Ibid, iv. p. 441, & Treatise on Prim. Geol., p. 180: Dr. Macculloch, System of Geology, i. p. 380: Mr. Bakewell, Introduction to Geology (4th edition), p. 420: Dr. Buckland, Bridgewater Treatise, i. p. 548: Mr. De la Beche, Geological Manual (3rd edition), p. 492; Theoretical Geology, p. 215; Report, pp. 317-322: Mr. R. W. Fox, Report of the Royal Cornwall Polytechnic Society (1836), p. 83: Mr. Burr, Mining Review, No viii. (May, 1836), p. 208, & Practical Geology, p. 40: Prof. Phillips, Encyclo. Metrop., Art. *Geology*, iv. p. 770; Encyclo. Brit. (re-published separately), p. 270; Lardner's Cabinet Cyclo., *Geology*, i. p. 44, ii. p. 120: M. Fournet, Etudes sur les dépots Métallifères, p. 17: and in almost every elementary treatise on Geology.

[2] "As even the richest lodes do not hold worth working throughout, we may "not be able to trace with certainty any lode for a great length."

MR. THOMAS, *Report*, p. 20.

See also Mr. Carne, Cornwall Geo. Trans., ii. pp. 89-96-106.

On the same series of *lodes* the workings at *Wheal Darlington*, the *Marazion Mines*, *Owen Vean*, &c., have been 2¼ miles long; at *Wheal Bolton*, *Rospeath*, *Great Wheal Fortune*, &c., 2 miles; at *Wheal Ann*, *Wheal Alfred*, and *Herland*, 2¼ miles; in *Wheal Vor*, 1½ mile; in *Binner Downs*, *Wheal Abraham*, *Crenver*, &c., 2¾ miles; through *Stray Park*, *Dolcoath*, *Cook's-kitchen*, *Tincroft*, and *Cairn Brea Mines*, 2¾ miles; at *Cardrew Downs*, *North Downs*, *Treskerby*, *Wheal Chance*, and *Chacewater Mine*, 3½ miles; in *Wheal Gorland*, *Wheal Unity*, *Poldice*, and *Creegbraws*, 2½ miles; at *Wheal Damsel*, *Carharrack*, *Wheal Maid*, and the *Consolidated Mines*, 2¾ miles; in *Ting Tang*, *Wheal Squire*, the *United* and *Union Mines*, 3 miles; and through *Charlestown*, *Crinnis*, *Pembroke*, and *East Crinnis*, 2¼ miles. The *lodes* and *branches* respectively belong to the same series in each of these tracts, but the identity in each case cannot be precisely determined.

invariably throw off into the containing rock *shoots*, *strings*, and *branches*, in such abundance, that instead of one *champion-lode*,[1] the whole forms a complex and irregular net-work of veins.[2] Often, too, the *lode* first discovered dwindles to a mere line, whilst some of its off-shoots swell out, enlarge, and rival, or even surpass, both in size and richness, the vein from which they have separated. It is, however, rather more frequently the case that the *lodes* split as they go eastward, than the contrary, as at *Wheal Bolton*, *Rospeath*, *Relistian*, *Ting Tang*, &c., and in the *lodes* of *Dolcoath*, which ramify in the neighbouring mines of *Cook's-kitchen*, *Tincroft*, and *Cairn Brea*: something of the same kind also occurs in *Wheal Friendship*. It is by no means uncommon for *lodes* to split directly at the point of their intersection by a *cross-course* or *flucan*, on one side of which the *lode* appears in two *branches*, whilst, on the opposite, but one occurs: this takes place at *Wheal Trenwith*, *Poldory*, and in many other places.

The veins which separate in this way sometimes re-unite both horizontally and vertically, and hence masses of the contiguous rocks, provincially called *horses of ground*, are on all sides surrounded by veins. These masses are met with in almost every mine; and examples of them are found in *Wheal Reeth*, *Binner Downs*, *Dolcoath*, *Cook's-kitchen*, &c.

The *lodes*, and *branches*, which thus traverse the rock, though individually not parallel to each other,

[1] The larger *lodes* are provincially called *champion lodes*.

[2] Prof. Sedgwick, Address to the Geol. Soc. (1831); Phil. Mag. & Annals (1831), ix. p. 283: Mr. Burr, Mining Review, No. viii. (May, 1836), p. 238.

may, on a large scale, and as a general fact, be considered to coincide in direction; but they dip in different ways, and at diverse angles, and thus often intersect each other, as at *Spearn, Park-noweth, Balleswidden, Wheal Darlington, Herland, Wheal Vyvyan, Poldory, North Downs, Wheal Music, South Wheal Towan, Polberrow, Wheal Prudence, Great Saint George, Polgooth, Carclaze, The Bunny, Fowey Consols,* and perhaps at *Wheal Friendship.* This kind of intersection seems neither confined to one kind of rock, nor to veins affording merely one description of ores; for some are in granite,[1] and others in slate;[2] and whilst the produce of several is only copper ore,[3] and of others only tin ore,[4] a few contain both minerals.[5]

The results of these intersections are as various as the conditions under which they occur; but it seems impossible to point out a general rule. Sometimes they unite and continue together for a considerable space, as at *Cook's-kitchen,* where at different spots *Toy's lode* accompanies the *South lode* and *Dunkin's lode,* but after several fathoms again separates from them. Sometimes one *lode heaves* or *throws* the other: the former condition may be examined at *Herland,* where *Bull's lode heaves* the *Caunter lode;* and the latter at *South Wheal Towan* and *Wheal Prudence,* where two *lodes,* having

1 At *Spearn, Park-noweth, Balleswidden, Wheal Vyvyan, Carclaze,* &c.
2 *Herland, Poldory, Polberrow, Wheal Music, Polgooth,* &c.
3 *Wheal Music, Great Saint George, Wheal Friendship,* &c.
4 *Polberrow, Balleswidden, Carclaze, Drake Walls,* &c.
5 *Wheal Darlington, Poldory, Wheal Vyvyan,* &c.

opposite dips, fall together on the lines of their inclination. In these instances the *lodes* which dip south are *thrown* upward by those which *underlie* northward; at *South Wheal Towan* 25 fathoms,[1] and at *Wheal Prudence* 8 feet; whilst in numberless other cases, as at *Wheal Vor*, *Ting Tang*, &c., the veins after thus falling together are not observed to separate again.

In some instances, near the point where two *lodes* cross each other, both seem to be in a state of disorder, and their distinct features to be lost for several fathoms. The intermediate space is filled with a quartzose rock, here and there spotted and spangled with ore; but a little further, the *lodes* resume their regular characters. Some remarkable examples of this description occur at the intersection of *Trevenson* and *Reeve's lodes*, in *East Wheal Crofty*.

It is a fact of some interest, and peculiar to the *lodes* of *Herland*, that they seldom preserve the same relative dimensions for any great distance. They frequently enlarge and contract, and though their greatest width is seldom more than a foot, they often taper away to a mere line, and then again expand. It however seldom or never happens that the broadest portions of two parallel *lodes* in that mine stand opposite to each other on the same meridian; for, almost without exception, the wider parts of one are opposed to the narrower parts of another.

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[1] The *lode* which dips N. splits into two *branches* in one part of its downward course, and a portion of the other *lode* lies within the *horse of ground* which is included between these *branches*.

1. *The relations between the lodes, and the containing rocks,* may be considered under the heads of structure and composition.

(*a.*) *Structure of lodes, shewing their connection with the rocks.*—The mechanical structure of the *lodes,* like that of the rocks, seems in some measure dependent on their mineral characters, which are very variable. Where they are most uniform in composition they consist chiefly of quartz; and there, as in the homogeneous clay slates, a jointed structure frequently prevails:[1] but in the more mixed and heterogeneous, which also form the largest portions of the *lodes,* this character is far less common.

The quartzose parts of *lodes* are often traversed by joints having the same direction as the *lodes* themselves, which are thus divided lengthwise into other sub-veins or plates, in some places termed *combs.*[2] But these joints do not long continue distinct and separate, for, like the joints already mentioned as existing in the rocks, they curve, unite, separate, and again fall together, and thus divide the substance of the *lodes* into irregular plates, which generally become thin above, below, and at either end, whilst the thicker portions of some of them fill up the

1 "When a lode breaks away in large jointed rocks, be it of what kind "soever, it implies no good for Copper or Lead."
MR. PRYCE, *Mineralogia Cornubiensis,* p. 95.

2 "A lode often appears to be composed of many smaller veins of different sub-"stances, which are frequently furnished with walls, sometimes very smooth."
MR. R. W. FOX, *Report of the Royal Cornwall Polytechnic Society* (1836), p. 89.
"The contents of parts of several lodes consist of a succession of plates of "mineral substances, varying much in their continuity, and to a certain extent "parallel to the sides of the fissure, between the walls of which they are "included." MR. DE LA BECHE, *Report,* p. 339.

concavities formed by the thinner portions of others. This structure prevails more in the Gwinear and Crowan district than elsewhere, and striking examples of it occur at *Binner Downs*, *Wheal Strawberry*, and *Godolphin*. The surfaces of these joints are often coated with crystals, when interstices afford room for their formation; in fact the whole substance of the *lode* in such localities has usually a crystalline character. But these appearances seldom or never reach far; for in such *lodes* as present the most decided and extensive examples of this veined structure, they seldom extend through more than a few feet or fathoms either in length or depth, and then gradually vanish.

It has been already shewn[1] that, in rocks, the joints and the *elvan-courses* frequently coincide in direction; this also very often happens with respect to the *lodes*, of which the portions more particularly metalliferous, when contained between two nearly parallel joints, thus appear to have *smooth walls*. Often, however, the joints after running in this manner for some distance, at length disappear, and as in the greater number of instances there is a gradual passage or transition between the mineral character and composition of a *lode* and its containing rock *(the Country)*: in all such cases, from the absence of the joints, the *walls* are said to be rough. Sometimes, notwithstanding the symmetrical lines may be still found to include the richer portions of the *lodes* between them, the intermediate substance, between

[1] *Ante*, p. 167.

the *lodes* and the containing rock, is metalliferous also. Veins, *strings*, and *branches* of ore may also penetrate this quartzose rock, which is provincially known by the name of *Caple*. Hence the occurrence of regular *walls* by no means indicates a sudden and strongly-marked distinction between the *lodes*, and the *Country*.

The *lodes* not only afford instances of a jointed structure parallel to their bearing, but there is frequently also a series of cross-joints by which the *lodes* are traversed, as at *Trevidgia*, the *United Mines*, *Charlestown Mines*, &c. Examples of a sort of horizontal *bedding*, or thick lamination, likewise abound in them, as at *Duffield*, *Wheal Buller*, *Wheal Friendship*, &c.; and a similar appearance prevails in the vitreous copper ore in some parts of *Levant*.

Near the separation between the *lodes* and the *Country* the joints are frequently filled with an unctuous clay *(flucan)*, which sometimes also is met with in those still nearer the central parts of the *lodes*, as at *Wheal Reeth*, *Dolcoath*, *Redmoor*, and *Wheal Friendship*.

Nearly akin to this jointed character are the *slickensides*, or polished and striated surfaces, which, sometimes of iron pyrites, but more usually of copper pyrites,[1] often cover the faces of the *walls* of *lodes*, as at *Great Wheal Fortune*, *East Wheal Crofty*, *Dolcoath*, the *Consolidated Mines*, and most

[1] *Slickensides* have occurred in the tin ore of *Polbreen* in Saint Agnes, in the vitreous silver ore of *Wheal Brothers*, and among the hydrous oxide of iron at Restormel. In lead mines, I believe, they are everywhere very common.

mines, in short, where copper pyrites abounds. These are also sometimes observed to run in a curved, serpentine, and most irregular manner, throughout the whole substance of such *lodes* as show no other trace of joints. At *Wheal Robert*, for instance, they intersect each other in every direction, and thus enclose angular, spherical, and most oddly-shaped masses.

Whether the faces of these divisional lines be coated with earthy or metallic substances they are almost always marked with striæ;[1] but although these may be abundant on either side of the *lode*, yet the directions of the striæ (to say nothing of their angles) seldom or never correspond; neither are they ever parallel for more than a few inches, but are generally divergent. In these lines breaks of continuity are common, and frequently those which for some distance are nearly straight, become curved and otherwise irregular. Again,—the faces on which these markings appear are never plane surfaces, but always have protuberances, lumps, pits, and hollows; and whether they project, or be depressed, are alike marked and polished with as much continuity and regularity as the rest.[2]

Beside the jointed and lamellar structure which prevails in *lodes* there is another[3] sort of much importance, and, although it is nowhere very extensive,

[1] As the faces of the joints in the granite of Tregoning-hill, *ante*, p. 172.

[2] Professor Phillips, Encyclopædia Metropolitana, Art. *Geology*, p. 776: and Mr. De la Beche, Researches in Theoretical Geology, p. 206.

[3] The brecciated structure which prevails in parts of some *lodes*, belongs properly to their composition, and will be described under that head.

yet traces of it may be seen in most parts of Cornwall. This may be called the conglomerated, or spheroidal structures.

In *Captain Benjamin Davy's lode*, at *Park-noweth*, are found globular quartz stones, which seem to be composed of several concentric layers surrounding a central ball. In the *Badger lode*, at *Herland*, are spheroidal pieces of quartz, slate, *elvan*, and granite, imbedded in some places in a granitic, in others in a slaty or quartzose basis or cement.[1] In *Relistian* round masses of slate are enclosed in quartzose slate, chlorite, tin ore, and in iron as well as in copper pyrites, and these stones are also frequently encrusted with crystals of tin ore:[2] in one spot a nodule of *elvan* was enclosed in the *lode*. At *Duffield* round pieces both of slate and *elvan* occur; and at *Trevaskus* balls of slate and of quartz often prevail: in some instances, I have also seen nodular lumps of copper pyrites imbedded in quartz.

In all these instances, except the first *(Park-noweth)*, which is in granite, a similar structure is even more evident in a layer of quartzy slate; *i. e.*, quartz through which the colouring matter of the containing rock has been diffused[3] *(Capel)*. In *Relistian*, *Duffield*, and *Trevaskus*, these nodules are not apparent in the rock until after it has been

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[1] My Lecture on Metalliferous Deposits, Edin. New Phil. Journal (1836), xxii. p. 166: also, Mr. De la Beche, Report, p. 323.

[2] Mr. Carne, Phil. Trans. (1807), p. 293.

[3] An excellent description of a compound rock of this kind, near Crosbane, is given by Mr. Weaver, Geo. Trans. o.s. v. p. 171.

broken: of the fragments, one then holds the projecting concretions, and the cavities which they had previously filled mark the other. In all these *lodes* this structure shades off into the containing rock, and not uncommonly one end of a piece of slate exhibits this spheroidal form, whilst the other passes off into the contiguous homogeneous slate, from which it is nowise distinguishable. In other places the slates, as well as the intermediate rocks and the *lodes*, affect a concretionary structure like that which I have remarked in the *elvan-courses* at *Relistian*, Redruth, and Pulla, and the unconnected globular masses of granite in the slate at *Herland*, and of *elvan* near Cairn Brea.

(*b.*) *The relations between the mineral composition of the lodes and the containing rocks.* 1. *Junctions between them.*—In the clay slates, where strings and beds of quartz form almost an integral part of the rock, the transitions between the *lodes* and the rocks are very perceptible, but are not always made with the same rapidity, or by precisely similar steps. Should the *lode* be equally rich for some length, the equi-metalliferous portions of it (to coin a phrase) do not in all parts maintain the same line; and, consequently, if all the rock containing equal quantities of ore in the same space were extracted, the sides of the excavation would be extremely ragged and irregular; or, in mining language, the *walls* would be rough. It will, however, be remembered that joints parallel to the direction of the *lodes* sometimes occur just on those portions of them beyond which their produce

is not worth pursuit, and cause the appearance of smooth *walls*, when the case is not really so.

It has been already remarked[1] that the chief ingredient in the *lodes* is quartz; but this is so mixed and incorporated with the substance of the containing rock, as in general to change its aspect entirely. In slate thin scales of the rock and certain particles of its colouring matter will tinge the *lode* of the same hue. This mixed quartzose rock prevails near the sides of the *lodes*,[2] and is not very often productive: should, however, the other parts of the *lodes* be rich, this also frequently contains small strings, and irregular and unconnected lumps of ore. The central portions of the *lodes* also often consist of a similar substance, and frequently, too, contain matter closely resembling the contiguous rocks, and distributed with great irregularity.

The schorl rocks associated with the slates are very beautiful. They have mostly a lamellar structure, and consist of very thin layers of white or very

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[1] *Ante*, p. 174.

[2] "Many parts of those veins, exhibiting what have been called regular "walls, are intimately connected with the adjacent rock, not only as it were by "a mechanical union, but often by a transition of mineral composition, * * *. "Sometimes indeed the vein itself at these points of union, appears to partake "of the nature of the containing rock." Dr. Boase, *Primary Geology*, p. 179.

"The sides of the lodes, especially tin lodes, are often principally composed "of quartz, combined with *peach* (chlorite) shorl, or disintegrated portions of "the containing rock, &c. These sides or boundaries of lodes, are usually "termed "*capels*," showing no smooth or regular walls, but penetrating into "the enclosing rock or "*country*," and also into the lodes, and mixing with "their other contents."

Mr. R. W. Fox, *Report of the Royal Cornwall Polytechnic Soc.* (1836), pp. 86-7.

"The same intimate connection which subsists between the quartzose part "of veins and the included portions of slate *(horses of killas)*, also obtains "between the veins and the main rock." *My own Lecture on Metalliferous Veins*, (Nov. 10th, 1836), *Edin New Phil. Journal*, xxii. p. 156.

light grey felspar, alternating with others of black schorl; in some cases it is probable that siliceous matter may be intimately mixed with both these ingredients: and at *Fatwork* mine, near the Indian Queens, layers of tin ore often replace those of schorl. The most interesting feature of this variety is its complicated curvatures and irregular figures: often, too, the same layers vary in thickness in different parts, and give the whole rock an additional singularity and complexity of character and appearance. This kind also passes, on one hand, into the *lodes*, as at Breage, *Poldory*, Roche, and Kit Hill: and, on the other, into the contiguous rocks.

Near the junction of the granite and slate the schorl and quartz are often, in almost microscopic crystals, most intimately mixed: the rock is of a bluish-grey, and to the eye, unassisted by the lens, appears homogeneous.

In granite the schorl rock is commonly a simple mixture of schorl and quartz, which, in fact, are often in distinct crystals, as at Polladan Cove, Roche Rock, *Carclaze*, &c. In such a state it often forms part of the *lodes*.

In granite the transitions between the rock and the *lode* are very similar to those between the slate and the *lodes*: but as in the granite the *lodes* are comparatively more felspathic than quartzose, and the association of felspar and quartz gives them a more granitic aspect, the passage is usually more gradual, and the chief distinction is that schorl is perhaps more general and abundant in the *lodes* than

in the rock; yet, on account of the greater simplicity of mineral composition, the change is completed sooner than among the soft clay slate, in which, as already stated, the veins of quartz are so conspicuous and important.

The case of the *Elvans* is an intermediate one, for the veins of quartz which strike off from the *lodes* disappear more suddenly than they do in the slate; whilst they are more numerous, and the mineral transitions are less speedily affected, than in the granite. Illustrative examples occur at *Great Wheal Fortune, Dolcoath,* and *Polgooth.*

In some places beds, nearly horizontal,[1] separate from the *lodes,* are productive at considerable distances from them, and, indeed, frequently extend from one *lode* to another, as at *Wheal Reeth* and *Wheal Vor.* The *tin floors* in slate at *Botallack-bunny*[2] have been long known, but they may be observed also in slate at *Wheal Vor,* and in granite at *Wheal Reeth* and *Wheal Speed:* copper ores occur, in similar floors, at *Wheal Friendship* in slate, and at *Wheal Trannack* in granite. The *Trevaunance lode* in *Polberrow* differs little, if at all, in character from these deposits.

It has been already remarked[3] that small veins often separate from the *lodes* and strike off into the

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[1] Dr. Borlase, Natural History, p. 161.

[2] Mr. Pryce, Mineral. Cornub., p. 81: Mr. Hawkins, Cornwall Geo. Trans., ii. p. 33: Mr. Carne, Ibid, p. 328, & Journal of Statistical Soc. (1839), ii. p. 260: M. Fournet, Etudes sur les Dépots, Métallifères, p. 232: and Mr. R. W. Fox, Report of the Royal Cornwall Polytechnic Society (1836), p. 83.

[3] *Ante,* p. 176.

rock, and there dwindle, die away, or come to nothing, others lose their metallic contents, alter their bearings and inclinations until they coincide with the cleavage planes or joints, and continue through the rock as integral parts of it, as at *Wheal Cunning, Herland, Binner Downs, Polladras Downs, Polgooth, Wheal Friendship,* &c.

In the vicinity of the *lodes* and strings the rocks not only alter in their mineral characters, but almost invariably become softer,[1] possibly from the action of water which the cellular or drusy character of the *lodes* allows to circulate more freely than it does in the rocks. From this cause, with few exceptions, the mining excavations require to be supported and kept open by wooden props and partitions,[2] which, however strong they may be, are sometimes insufficient for their intended purposes.[3]

The masses of rock *(horses of ground),* already mentioned, which are on all sides enclosed by the

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[1] Mr. R. W. FOX, Report of the Royal Cornwall Polytechnic Soc. (1836), p. 88: and Mr. Burr, Mining Review (Dec. 1837), p. 186.

[2] The annual consumption of Norway debenture timber in the Cornish mines,—for ten years, ending 1827, averaged 11,845 loads; and for ten years, ending 1837, 19,457 loads: taking four trees to the load of timber, the numbers will respectively be 47,380 and 77,828 trees.

SIR. C. LEMON, BT., *Journal of the Statistical Society*, i. (June 1838), p. 81.

[3] The decomposing influence of the air on greenstone is very remarkable. Rocks of this kind, which at first the labourer can with difficulty penetrate, within a few weeks after they have been opened become so soft, and have their joints, which were hardly discernible, so freely displayed, that strong and close boarding is required in order to keep the *levels* open; and even then the wood is often slowly and almost imperceptibly crushed, and the workings are closed. In some measure this also happens in granite after its exposure to the air; but with more certainty, and to a far greater degree, if a recent excavation be allowed to fill with water. This softening of the rock is locally called *mawing*, a provincial term applied also to the thawing of a frozen substance.

lodes and *branches*, are composed sometimes of one, sometimes of different kinds of rock, according to the locality: where, however, they occur at a junction of two rocks, the line of the contact of such rocks is prolonged through the enclosed masses *(horses)* in a conformable position, and with as much regularity as in the *walls* of the enclosing veins, as at *Cook's-kitchen*, and *Dolcoath*.

I wish to observe here that the *lodes*, *branches*, and the portions of rock included between them, form a very considerable proportion of the entire mass:[1] whatever forces may have caused the present structure of the rocks, and produced the *lodes*, they do not seem to have occasioned any motion in the parts thus enclosed.

(*b.*) 2. *The composition of lodes in different rocks.*[2]—The general law seems to be that a change of rock

1 "On the supposition that veins were originally fissures, Cornwall must "have been subject to innumerable convulsions; and in some districts the total "thickness of these openings must have borne no inconsiderable proportion to "the whole mass. In St. Just, for instance, within a single mile, how nu- "merous the parallel lodes are which have been worked; and these are few "compared with those that have not been examined, and still more so with "those veins that are not metalliferous." Dr. Boase, *Primary Geology*, p. 359.

2 This was first noticed by Dr. Borlase, who says:—

"If the general run of the neighbouring *strata* be of any particular colour, "be lax or compact, be of a spar or crystal cement, be of slat, granite, or any "other stone, so will the lode be for the most part." *Natural History*, p. 147.

It has also been alluded to and described by Mr. Pryce, Mineral. Cornub., p. 94: Mr. Carne, Cornw. Geo. Trans., iii. p. 78: Dr. Boase, Ibid, iv. p. 441, & Prim. Geol., p. 168: Mr. Burr, Mining Rev., No. viii. (May, 1836), p. 218: Mr. R. W. Fox, Report of the Royal Cornwall Polytechnic Soc. (1836), p. 84: Mr. Bakewell, Introduction to Geology (4th edit.), p. 430: Dr. Macculloch, System of Geology, i. p. 386: Professor Phillips, Encyclo. Metrop. *Geology*, p. 772,—re-printed from the Encyclo. Brit., p. 272; Lardner's Cabinet Cyclo., ii. p. 134: Mr. De la Beche, Geological Manual (3rd edit.), p. 492; Researches in Theoretical Geology, p. 218; Report, p. 335: My own Papers, Phil. Mag. and Annals, x. (1831), p. 460; Edin. New Phil. Journal, xxii. (1837), pp. 156-271; Annals of Electricity, i. (1837), p. 124; Annales des Mines, xi. (1837), p. 586.

is characterized by an instant and corresponding alteration in both the metalliferous and earthy minerals of the *lodes*. This, as might have been expected, is much more remarkable where the rocks are very dissimilar than when their compositions vary but slightly. In the Saint Just district vitreous copper ore occurs at *Levant, Botallack, Wheal Cock,* and in most of its mines worked in the greenstone; whilst tin ore is the only produce of *Wheal Bellon, Wheal Cunning, Boscaswell Downs,* and, in short, of all those which are wholly in the granite. In the Saint Ives district vitreous copper ore and copper pyrites are almost the only metallic minerals found at *Wheal Trenwith, Providence Mines,* and others worked in the greenstone, and slate formation; whilst, in the granite, at *Saint Ives Consols, Rosewall Hill, Balnoon, Wheal Reeth, Wheal Mary,* &c., only tin ore is found. The Gwinear and Crowan district is chiefly in the slate formation, and copper pyrites is the product of the mines in that rock, except in certain cases to be mentioned presently. At *Great Work,* in the Helston district, the passage of *Wheal Breage lode* from granite to slate is attended by the instant disappearance of the tin ore it contained in the former.[1] On the other hand, at *Wheal Vor,* in the same neighbourhood, the *lode* is productive of tin ore in slate, and becomes utterly worthless in granite. In *Great Work* it must however be noticed that the granite is micaceous, whilst

[1] Mr. Carne, Cornwall Geo. Trans., ii. p. 93 : My own Paper, Edin. New Phil Journal, xxii. p. 157 : Mr. De la Beche, Report, p. 328.

in *Wheal Vor* it contains talc also; and that the slate rock of the former is a greenstone, but that of the latter a lamellar and dark blue passing into a purplish slate, In *Dolcoath, Cook's-kitchen,*[1] *Tincroft,* and the *Cairn Brea Mines,* the *lodes* in the granite in general contain more tin ore than they do in slate, and frequently more of vitreous, and earthy black copper ores also; and, almost invariably, a much larger proportion of earthy brown and red iron ores. In the Saint Austell district copper ores abound in the schistose slate rocks at *Pembroke, East Crinnis,* and *Fowey Consols;* but in the quartzose slate of *Polgooth,* the micaceous slate of *Charlestown Mines,* and throughout the granitic tract of that neighbourhood, tin ores only are found. The granite of Kit Hill, and of Dartmoor, have hitherto, with a single exception, yielded tin ore only; whilst the slate series of that district affords the ores of copper, lead, and silver, but those of tin very sparingly, as at *Drake Walls,* &c.

Small quantities of vitreous copper ore occur in the granite, near its junction with the slate, in *Levant, Wheal Edward,* and some other of the mines in Saint Just; and in similar situations, and mixed with native copper and copper pyrites, at *Wheal Speed,* and *Providence Mines* near Saint Ives. At *Great Work,* and in *Wheal Vor,* a little black copper ore occurs in the granite; and at *Wheal Trewavas* and *Wheal Trannack,* in the same neighbourhood, vitreous

[2] Mr. R. W. Fox, Report of the Royal Cornw. Polytechnic Soc. (1836), p. 85.

copper ore and copper pyrites have been plentiful in the same rock. In the granite of the Camborne district, near the junction of the slate, vitreous copper ore, mixed with copper pyrites, has occurred at *Dolcoath*, *Cook's-kitchen*, *Tincroft*, and the *Cairn Brea Mines*. *Wheal Buller*, in the Gwennap district, has yielded vitreous copper ore and copper pyrites, both in slate and in granite, but far more plentifully in the former, and, in the latter, only at small distances from the junction: in *Tresavean* the *lode* affords enormous quantities of copper pyrites in the granite, but is exceedingly deteriorated in value on entering the slate;[1] a similar fact presented itself in the adjoining mine of *Penstruthal*. In the same neighbourhood the *lodes* of *Wheal Jewel* and *East Wheal Damsel* have produced copper pyrites whilst in slate, but vitreous and black copper ores only when they enter the granite. At *Gunnis Lake*, which is in granite (on the declivity of Kit Hill), vitreous and black copper ores are almost the only metallic minerals.

At *Great Wheal Fortune* the *lode* runs for a short distance with slate on one side and *elvan* on the other: the side in contact with the slate is a spotted bluish-green quartzose slate, with spots of copper pyrites; and the other is also of quartz, but much mixed with felspar, and contains a sprinkling of vitreous copper ore. At *Dolcoath* the *Caunter lode* runs for several fathoms between *elvan* and slate on both sides of the *elvan-course*; and, in either case, is

[1] My own Paper, Edin. New Phil. Journal, xxii. p. 157.

alike tolerably productive of vitreous copper ore, but, during its passage through the *elvan*, it is small and split into numerous strings, and scarcely worth working. In *Ting Tang* the *lode* yielded copper pyrites, vitreous and black copper ores, the carbonates, arseniates, the silicate, and the oxide of copper, with abundance of native copper, whilst in *elvan;* in slate it was almost wholly a quartzose slate; in granite, however, it was almost entirely *(gossan)* earthy brown iron ore,

At *The Wherry*, and *Parbola*, veins of tin ore penetrate the *elvan* in all directions; but disappear immediately on touching the slate. In *Relistian*, *Wheal Vor*, and *Wheal Unity Wood*, the *lodes*, which yield tin ore in abundance whilst in the *elvan*, become altogether unproductive in the adjoining slate.

It may further be remarked that as we ascend in the slate series, and approach either the more extensive deposits of its organic remains on the north coast, from Ligger-bay eastward, or those rocks in which traces of carbonaceous matter are found, near Boscastle, and in the neighbourhood north of Tavistock, the *lodes* contain more and more of galena.

The position and configuration of the granite masses seem to exercise an influence on the disposition or arrangement of ores contained, not only in the *lodes* which occur in that rock itself, but also in those which traverse the slates adjacent thereto: for the masses or *shoots* of ore in any given *lode* have,

generally speaking, a prevailing dip, and whether they occur in granite or in slate, whether on the eastern or western side of the granitic tracts, this inclination is invariably towards the great body of the slate.[1]

At *Botallack* one of the *lodes* passes no less than three different times from granite into slate, and at every change in the granite it yields tin ores only, but wherever it traverses the slate its metallic produce is wholly vitreous copper ore: other cases of a like nature might be mentioned, but, notwithstanding these, the general fact seems to be that the same *lode* is seldom productive in adjoining rocks of different descriptions.[2] Variations in the character and composition of rocks of the same series are accompanied by great changes of the *lodes* by which they are traversed; but this important fact may be more appropriately discussed in a subsequent part of this Memoir.[3]

Notwithstanding the enormously rich *bunches* of tin ore which have occurred in slate at *Wheal Vor*, Saint Agnes, *Polgooth, Charlestown Mines*, and in

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[1] My own Paper, Edin. New Phil. Journal, xxii. p. 157. This view of the disposition of *shoots* of ore embraces those which are found in the granite, as well as these in the slate series. It therefore includes that of Mr. Tregaskis, which has subsequently been quoted by Mr. R. W. Fox, Report of the Royal Cornwall Polytechnic Society (1836), p. 95.

[2] "It is rarely the case that a lode which has been productive in one rock, continues rich long after it has entered another."

MR. CARNE, *Cornwall Geo. Trans.*, iii. p. 79.

"Many lodes which yield abundance of ore in granite, are unproductive in "killas, and vice versâ."

MR. R.W. FOX, *Report of the Royal Cornwall Polytechnic Soc.* (1836), p. 88.

Mr. Burr, Mining Review, No. x. (Dec. 1837), p. 180.

[3] On the circumstances which seem to affect the metallic contents of *lodes*.

some other spots; and the valuable discoveries of copper pyrites in granite at *Tresavean*, and in the massive slate rocks at *North Roskear*, *East Wheal Crofty*, and in some parts of *Dolcoath* and *Cook's-kitchen*, yet, on a general view of the whole tract under consideration, it will appear that the *lodes* in granite, *elvan*, and the massive varieties of the slate series, have yielded beyond comparison the largest quantities of tin ore, and of the vitreous and earthy black ores of copper, together with the rare and uncommon crystallized varieties and compounds of that metal; whilst the *lodes* which traverse the schistose slates have chiefly afforded copper pyrites, usually in the massive form, and but seldom any other varieties of copper ores.[1]

2. *The composition and structure of the rocks which form the opposite walls of lodes.*—If at a distance from the junctions of the slate rocks with granite or the elvans, and in either of these rocks, we take areas of small extent, we shall commonly find their characters and compositions so uniform, that no particular beds or layers can be accurately identified even at minute distances: probably on this account it has been taken for granted that the rocks which compose the opposite sides of *lodes* have a perfect correspondence with each other. It is not, however, in such situations that we must look for decisive evidence on a point of so much importance: but in those localities where the junctions of

[1] My own Papers, Edin. New Phil. Journal, xxii. (1837), pp. 157-271; Annals of Electricity, i. (1837), p. 125; Annales des Mines, xi. (1837), p. 587.

rocks, differing in mineral composition, and mechanical stucture, present features which cannot be mistaken, and indications which cannot be confounded.

For had the surfaces of rock, now separated by the intervention of the *lodes*, been united at the time of their first solidification, we should see an exact coincidence between their mineral and mechanical characters, markings, &c.: even when they were found at different levels on opposite sides of the *lodes*, the direction of such a motion, as might bring them again in contact, and make their distinctions exactly to fit each other, ought to be evident.

On account of the few localities in which such particulars could be examined I have paid the closer and more careful attention to the facts which have come under my notice, with a view to the confirmation or contradiction of this supposed correspondence.

(*a.*) At *Botallack* the *lode* runs for 20 fathoms with granite on one side, and slate on the other, and in the S. *wall* there is a vein of granite traversing the slate which does not appear in the same rock on the opposite side of the *lode*.

(*b.*) At 114 fathoms deep in *Levant* a similar vein of granite occurs in the slate of the W. *wall*, but is not seen on the E. side of the *lode*.

(*c.*) In *Providence Mines*, at 58 fathoms deep, the granite in the S.E. or upper *(hanging) wall* is 6 or 8 fathoms further N.E. than in the opposite; at 76 fathoms deep the N.W. lower *(foot) wall* is 10 fathoms further N.E. than the other; and, at 86 fathoms deep, the junction is on the same line in opposite *walls*.

At 76 fathoms deep a granite vein, 4 to 8 inches wide, dipping N., occurs in the N.W. *wall;* and on the S.E. side, at 83 fathoms deep, and 9 fathoms W. of the spot last mentioned, another granite vein extends from the main body of the granite about 7 fathoms into the slate; it is about 8 inches thick near the junction, but thins off to an edge as it recedes from the granite.

(*d.*) Granite veins are much more numerous in the N. or *hanging wall* of *Carleen lode* in *Wheal Vor,* at 68 fathoms deep, than in the opposite one. At 75 fathoms deep, in the same mine, a thick bed of granite intersects the slate, and dips E.: between this and the mass of the granite the intervening space is also traversed by numerous small granite veins; but this phenomenon is confined to the N. *wall,* for neither the bed nor the veins appear in any part of the opposite side of the *lode.*

(*e.*) At *Wheal Trannack* the *lode,* at 34 fathoms deep, continues for 10 fathoms with granite on the S. *(hanging) wall,* and slate on the N. At 44, 64, and 74 fathoms deep, beds of granite appear in the slate on both sides of the *lode.*

(*f.*) At 197 fathoms deep, near *Harriet's lode* in *Dolcoath,*[1] which is there split into two *branches,* a bed of fine grained schorlaceous granite intersects the slate of both *walls,* and also the *horse* of slate

[1] Captain Petherick, the intelligent manager of *Dolcoath,* informs Mr. R. W. Fox, that in that mine, " in one of the lodes (the caunter) the hanging wall is " evidently lower than the foot wall."

Report of the Royal Cornwall Polytechnic Society (1836), p. 92.

which is included between the two veins, whilst in all three its bearing and dip are conformable.[1]

(*g.*) At *Cook's-kitchen*[2] *south lode* there is granite in the S. *(hanging) wall*, and slate in the opposite, at 54 fathoms deep; and, at the same level, granite stands also on the S. (but in the *foot) wall* of *Toy's lode*, and a *horse of ground* between two *branches* of it is partly of granite and partly of slate, and conforms to the positions of these rocks on either side. At *Dunkin's lode*, in the same mine, the N. *(foot) wall* is granite, and the S. *wall* slate, traversed by several granite veins at 48 fathoms deep: at 52, 55, and 68 fathoms deep, the N. *(foot) wall* is slate, and the opposite is of granite; the composition, however, of the latter is not exactly alike in all these spots. At 73 fathoms deep the S. *wall* is again of slate, whilst the opposite side is of granite. The *Middle Engine lode*, at 33 fathoms deep, has the N. *(hanging) wall* of slate, and the *foot wall* of granite; but, at 73 fathoms deep, both sides are of the latter rock. At 54 fathoms deep the N. *(hanging) wall* of *Hardshaft lode* is of slate, and the S. of granite.

(*h.*) In *Tincroft*[3] a mass of granite accompanies *Dunkin's lode* from the surface to 26 fathoms deep; but, at a short distance on each side of this granite,

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[1] This is not the mass of granite described by Prof. Sedgwick, Cambridge Phil. Trans., i. p. 122, and figured in Mr. De la Beche's Report, Pl. viii.

[2] Mr. Thomas, Report, pp. 10-33: Mr. Carne, Cornw. Geo. Trans. ii. p. 75: Mr. Hawkins, Ibid, p. 378: See also my own description, Phil. Mag. & Annals, x. (1831), p. 360.

[3] Mr. Thomas, Report, pp. 10-43: Mr. Wm. Phillips, Geo. Trans., ii. o.s. p. 152, Pl. vii. fig. 8.

and also in both *walls* of the *lode* from 26 to 84 fathoms deep, slate is the only rock.

(*i.*) Granite extends from the surface to 29 fathoms deep at *Davey's lode* in *Wheal Beauchamp*, and it appears at the same level on both sides; but, at the *north lode*, the granite occurs 10 fathoms further E. in the S. *(foot) wall* than in the opposite, at 50 fathoms deep.

(*j.*) At all depths, in *Tresavean*, the granite extends 5 or 6 fathoms further E. in the N. *(foot) wall*, which is furthest from the main body of that rock, than it does in the opposite side.

(*k.*) At *East Wheal Damsel*, and *Wheal Jewel*, as far as the workings have extended, the junction of the granite and slate are conformable on both sides of the *lodes*.

(*l.*) Beds of fine grained granite occur in coarser varieties of the same rock, on one side of the *lodes*, both in *Park-noweth* and *Ding Dong*, but are not seen on the other.

The *elvan-courses*, when intersected by *lodes*, exhibit similar phenomena.

(*m.*) The N. *wall* of the *lode* at *Gwallon* is wholly *elvan*, and the S. entirely of slate; the *lode* holds a perfectly regular course between the two rocks.

(*n.*) At *Wheal Darlington elvan* appears on both sides of the *north lode*, at 30, and also at 40 fathoms deep; but, at the latter depth, there is less of it on the S.W. (or *hanging) wall*, than in the other. At 70 fathoms deep another *elvan-course* occurs in the S.W. *wall;* and, on the opposite side of the

lode there is slate for some fathoms. At 70 and 80 fathoms deep *elvan* appears in the N.E. *wall* several fathoms before it does in the other.

(*o.*) In *Herland* an *elvan*, which dips W., is intersected by the *Fancy Caunter lode*, which dips S.W., and is found 6 feet higher on the N.E. *(foot) wall* of the *lode* than in the opposite: another *elvan*, which dips N.W., is traversed by the *Convocation lode*, dipping S.E., and is some fathoms higher in the S.E. *(hanging) wall* than in the other. But, in the same mine, the *Manor lode* cuts through a nodular mass of granite which is imbedded in the slate, and is found at the same level on both sides of the *lode*.

(*p.*) At *Duffield* the *South lode* intersects two *elvan-courses;* the northern one appears in the S. *(foot) wall* several fathoms higher than it does in the N. *wall;* the other *elvan* is simply cut through, and stands at the same level on both sides of the *lode:* both elvans dip N., and the *lode* underlies in the same direction.

(*q.*) In Trevellas Downs some *lodes* intersect an *elvan-course* on the line of its dip, and throw it upward several fathoms; it is thus found lower in the *hanging* than in the *foot walls* of the *lodes*. This *elvan* dips N., and the *lodes* have an opposite inclination.[1]

(*r.*) At *Polgooth, Saint Martin's lode* intersects the *little elvan*, whilst *Reskilling great elvan heaves Screed's lode* 6 feet towards the right hand. The

[1] Mr. Conybeare, Geo. Trans., iv. o.s. p. 401, Pl. xxiii. fig. 2. My own Paper, Report of the Royal Institution of Cornwall (1838), p. 33.

two *elvans*, however, intersect, and at the point of their contact *Saint Martin's lode* falls between them and dwindles to nothing, but re-appears at a distance of 7 fathoms towards the right hand.[1]

(*s.*) At *Dolcoath* the *lode* and the *elvan-course* fall together diagonally, and on either side of the *elvan* the *lode* for some distance runs between it and the slate for several fathoms; the portion connecting these opposite parts cuts through the *elvan* nearly at right angles.[2]

(*t.*) In *West Poldice* unconnected masses of *elvan* occur in the slate. At 30 fathoms deep the N. *(foot) wall* is *elvan*, and the opposite one is slate; at 40 fathoms deep the N. side is of slate, and the S. of *elvan;* whilst, at 50 and 60 fathoms deep, *elvan* appears in two places, and in all these cases in a conformable position in both *walls*.

(*u.*) In far the greater number of cases, however, the *elvans* are simply traversed by the *lodes*, whether they intersect on the lines of their direction or dip. This is the case at *Marazion Mines, Great Wheal Fortune, Wheal Vor, Stray Park, Cairn Brea Mines, East Pool, Wheal Buller, Ting Tang, The United* and *Consolidated Mines, Cardrew Downs, Wheal Prudence, Wheal Budnick, Redmoor*, &c.

(A.) In the instances in which the opposite *walls* of *lodes* exactly resemble each other, where, for example, a *lode* simply passes through an *elvan-course* without *heaving* or *throwing* it out of its general

[1] Mr. Hawkins, Cornwall Geo. Trans., i. p. 151, Pl. 5. *Ante*, p. 128, Pl. ix. fig. 11.

[2] Pl. vi. fig. 3.

conformity in bearing and dip (*f, h, k, u*), or where one side is wholly of one rock and the opposite of another (*m*), the fact may be sufficiently explained by supposing a simple longitudinal rent on the bearing of the *lode*.

This solution may also be in some respect applicable where different portions of a *lode* continue in distant parts of its length to run between the *elvan* and the slate, although on opposite sides (*s*): but in this case one part of the *elvan-course* must have stood alone and unsupported, though inclining at an angle of 45°, and a contraction of the longitudinal dimensions of that rock must also have taken place to permit the continuity of the *lode* being preserved through it.

(B.) Where at one level the granite on one side of the *lode* extends further in a given direction than it does in the opposite, whilst, in regard to the same rock and *lode*, the fact is reversed at another spot, it is evident that at some intermediate point the granite must inevitably occupy a coincident position in the opposing *walls:* in such a case a curvilinear motion of the *walls*, with this neutral point as a centre, might have afforded an explanation. In the only example, however (*c*), a second coincidence in the rock occurs at a deeper part, and thus forbids the application of such a theory.

(C.) Where the intersected rock is not at the same level on opposite sides of the *lode* (*n, q*), or where the position of rocks differs throughout, as, for instance, when the junction of granite and slate, at all

depths, extends further in a given direction on one side of a *lode* than on the other (*i*,*j*), the elevation of one *wall* or the subsidence of the other seems to afford a ready solution.[1]

But the same *lodes* which intersect different rocks at different *levels*, on opposite sides, frequently also cut through such rocks when they exactly coincide with each other in their positions on the opposing *walls* (*c*, *g*, *h*, *n*, *o*, *p*, *t*). In these cases the motions required to bring the discordant portions together, would produce equal, if not greater, breaches in the continuity of those which now agree.

In like manner, if we take isolated examples, and apply one solution to one fact, another to a second, and a third to others, many difficulties would vanish. The chief obstacle in all these is, however, their connections; for when all these circumstances are found in the same localities, and often within a few fathoms, or even feet, of each other, is it possible to apply all the foregoing explanations (and many might be necessary) to the different examples as they occur?

(D.) But further, there is a very large proportion of instances in which the opposing faces have no sort of resemblance to each other; as, for example, where numerous beds and veins of granite traverse the slate in one *wall* of a *lode*, whilst there is nothing of the kind in the other (*a*, *b*, *d*); or where similar beds of fine grained granite occur in a coarser

[1] This idea was adopted by Mr. Pryce, Mineralogia Cornubiensis, p. 106. Mr. De la Beche also employs it in his speculations on the origin of *lodes*, Researches in Theoretical Geology, p. 207, fig. 38; Report, p. 344, fig. 66.

grained granite on one side of a *lode*, but do not appear in the opposite (*l*). From facts like these, which are numerous, it is hardly necessary to state the obvious conclusion, that these dissimilar rocks can never have formed continuous portions of an unbroken mass.

3. *The general composition of the lodes.*—The most cursory reference to any of the preceding tables, or to the details which accompany them, will at once show that much the largest proportion of the mineral composition of the *lodes* consists of quartz. Near the surface this is full of hollows and drusy cavities, is often more or less mixed with earthy brown iron ore, varies extremely in hardness and depth of colour, and is provincially called *gossan*.[1]

For the most part, when *gossans* contain metallic substances, they are tolerably hard, and their ferruginous matter is almost a chocolate brown; but they may contain softer portions; for example, a friable quartz, locally called *sugary spar*;[2] and also felspar clay, often called *prian*.[3] *Gossans* of this nature are more frequently found to accompany the ores of copper than those of other metals.

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[1] Dr. Borlase, Natural History, p. 197: M. Jars, Voyages Métallurgiques (1765), iii. p. 192: Mr. Pryce, Mineral. Cornub., pp. 88–89: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 117: Mr. Carne, Cornwall Geo. Trans., ii. p. 95: Mr. Burr, Mining Review, No. vi. (1832), p. 221, No. x. (1837), p. 171: Mr. R. W. Fox, Report of Royal Cornw. Polytech. Soc. (1836), p. 85: Mr. De la Beche, Report, p. 326.

[2] Mr. Pryce, Mineral. Cornub., p. 92: Mr. Carne, Cornw. Geo. Trans., ii. p. 101: Mr. Burr, Mining Review, No. x. (1837), p. 171-2: Mr. R. W. Fox, Report of Royal Cornw. Polytech. Soc. (1836), p. 86.

[3] Mr. Pryce, Mineral. Cornub., p. 90: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 119.

In many parts of this County, from time immemorial, the *gossans* have been worked for tin ores,[1] as at *Levant, Cairn Brea Mines,* and *Wheal Spinster,* and more recently for silver ores, of which small quantities are found[2] at *Wheal Falmouth, Ball-due,* and in some other places. In these superficial portions of the *lodes* much iron pyrites *(mundic)* has been found at *Wheal Bolton, East Wheal Crofty, Pennance, Ball-due, United Mines, Wheal Devonshire, East Crinnis, Virtuous Lady,* &c.[3] In similar situations blende[4] is also of frequent occurrence, as at *Union, United,* and *Consolidated Mines, Ball-due,* and *Wheal Hope,* and in *Wheal Prudence, Wheal Budnick,* and many other mines at Saint Agnes. Galena, too, has not rarely been found under like circumstances, as in *East Wheal Crofty, Wheal Budnick, Wheal Friendship, Redmoor, Wheal Brothers,* &c.

The shallower portions of the *lodes* also frequently yield earthy black copper ore, disseminated through the *gossan,* as in *Spearn Moor, Botallack, Wheal Kayle, Wheal Jewel, The Consolidated Mines,* &c. Native copper, and its red oxide, as well as its carbonates and arseniates, have also abounded among the

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1 Mr. Pryce, Mineral. Cornub., p. 44: Mr. Carne, Cornw. Geo. Trans., ii. p. 102, iii. p. 37: Mr. R. W. Fox, Report of Royal Corn. Polytech. Soc. (1836), p. 85: Mr. De la Beche, Report, p. 326.

2 Mr. Burr, Mining Review, No. x. (1837), p. 172.

3 The frequent occurrence of iron pyrites in the shallow parts of those *lodes* which have become rich at greater depths has originated the local proverb,—"mundic rides a good horse." See Mr. Pryce, Mineral. Cornub., p. 42: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 121: Mr. Burr, Mining Review, No. x. (1837), p. 172.

4 Mr. Pryce, Min. Corn., p. 93: Mr. Wm. Phillips, Geo. Trans. o.s. ii. p. 121.

gossans of *Levant, Botallack, Dolcoath, Wheal Buller, Penstruthal, Ting Tang, Wheal Gorland, Wheal Unity, Wheal Charlotte, Great Saint George, Pembroke, Gunnis Lake*, &c.

It may be noticed here that the greater number of rare and curious crystalline minerals occur in the shallower portions of the *lodes*, and usually where *gossan* is plentiful: and, again, that these rarities are seldom found in connection with large quantities of ore,[1] although the same *lodes* may be productive when these are absent; as, for example, at *Botallack, Spearn Moor, Wheal Alfred, Dolcoath, Wheal Tolgus, Wheal Buller, Penstruthal, Ting Tang, Wheal Charlotte, United Hills, East Crinnis, Pembroke, Gunnis Lake, Virtuous Lady*, &c.

Copper pyrites now and then occurs in *gossan*, but very rarely.[2]

But *gossan*, though for the most part confined to the shallower portions of the *lodes*, is sometimes found at very great depths, as in *Dolcoath, Wheal Reeth, Ting Tang, Wheal Gorland*, &c.: such cases are unusual, and are, perhaps, more common in granite than in other rocks.

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[1] In producing the crystallization of double chlorides, by electric forces emanating from a single pair of plates, M. Becquerel remarks that "the crystal "is complete at first, but when the apparatus has been a long time in operation, "the angles of the crystal become gradually truncated. It would seem from "that circumstance that when the particles of the substance which crystallizes "are not sufficiently abundant, the force which determines the regular grouping "of these particles has no longer the energy requisite to complete the crystal." *Traité de l'Electricité et du Magnetisme* (1835), iii. p. 312: *Taylor's Scientific Memoirs*, i. p. 431.

The analogy between this experiment and the fact stated in the text is too remarkable to be overlooked.

[2] I have seen fine specimens of copper pyrites in *gossan* at Cae Mawr, near Dolgelly, in North Wales.

However much the surface may undulate, still the upper parts of the *lodes* present the same appearances, and the *gossan* and other substances which usually accompany them are found as far below the surface, where they traverse valleys, as when they run through hilly ground.[1]

The foregoing pages have shown that the ores of copper and tin are often intermixed in the same *lodes*, as at *Botallack, Levant, Wheal Darlington, Marazion Mines, Saint Ives Consols, Dolcoath, Cook's-kitchen, Tincroft, Cairn Brea Mines, Wheal Jewel, Poldice, Wheal Unity Wood, Wheal Friendship*, &c. In most *lodes*, however, the one or the other is commonly the prevailing mineral, and in those most prolific of copper ore, *gossan* is generally plentiful; whilst it is often scarce where tin ore abounds. When there is no *gossan* the shallower portions of the *lodes* consist of a blackish quartz, which in slate is sometimes mixed with slaty matter *(capel)*, and in granite with schorl.[2]

In *lodes* which contain *gossan* near the surface, at greater depths there is generally a diminution of its ferruginous ingredients. Where copper ores abound the earthy black copper ore at first is mixed with the *gossan*, the proportion of iron ore decreases,

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1 "Veins commonly possess the same general appearances in valleys as in the "contiguous hills, * * * in both situations the metalliferous veins are in gene- "ral equally furnished with '*gossan*,' or other foreign matter overlying the ore."
MR. R. W. FOX, *London and Edin. Phil. Mag.*, i. (1832), p. 339.

2 The term *scovan*, which has now fallen into disuse, was formerly applied to *lodes* which afford no *gossan*. See M. Jars, Voyages Mètallurgiques, iii. p. 193; Mr. Pryce, Min. Corn., p. 90; Mr. Wm. Phillips, Geo. Trans. o.s. ii. p. 118.

and that of the copper increases; whilst, in those portions of the *lodes* which are unproductive immediately beneath the *gossan*, the ferruginous particles are replaced by hard milk-white quartz. In either case the transition is effected by gradual and almost imperceptible alterations in the mineral composition, in perfect analogy with those already described as occurring between the *lodes* and the containing rocks.

Notwithstanding the *lodes* are sometimes divided by longitudinal, and at others by transverse joints, often uniting below and at either end, and occasionally afford traces of horizontal bedding, these appearances are mostly confined within narrow limits, whilst the far larger part of every *lode* exhibits no trace of any particular arrangement or configuration. Frequently, however, the prevailing mineral runs continuously through the *lode* for considerable lengths and depths, forming what is provincially called *the leader*;[1] but it is equally or even more common for all the components to be mixed with great irregularity. In the latter case either of them may, for a short space, form small veins, spangles, unconnected lumps, &c.; whilst, within a few feet, the order is reversed, and the previously included mineral becomes a portion of the matrix. These exchanges of condition may be effected, at short intervals, in several, or even all, of the mineral substances forming the *lode*. Sometimes the minerals of which the *lodes*

[1] Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 138.

are composed are compact and perfectly solid, at other times they abound in cavities and hollows.[1] These may occur indifferently in any one of the ingredients,—they vary greatly in their dimensions: sometimes they are not larger than the cells of a honey-comb,[2] whilst in others they are several fathoms in length and depth.[3]

It has been already stated that the compact portions of the *lodes* are chiefly siliceous:[4] and sometimes the whole substance may entirely consist of minerals of this description; at other times the *lode* is almost wholly composed of ore. It, however, seldom happens that the alteration from poverty to riches takes place abruptly and at once, for the change is almost always effected by a very gradual increase of the metallic minerals; and, although the manner of their appearance and the mode of their distribution is by no means uniform, yet it is generally introduced by the occurrence of small spots and lumps of ore dispersed through the other

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1 This vesicular structure is locally called *sucked*. See also Mr. W. Phillips, Geo. Trans., o.s. ii. p. 118.

2 As at *Relistian*, *United Mines*, &c.

3 At *Dolcoath* a *vugh*, "from eighteen to twenty fathoms in length, three fathoms "high, and from four to nine feet wide," occurred in the *main lode*. Instead of a single large cavern, it, however, consisted of an infinity of small ones, opening into each other; or perhaps it may be more correctly described as a part of the *lode* filled with vesicular carbonate of iron. See Mr. Rule, Cornwall Geo. Trans., i. p. 225.

At the *Consolidated Mines*, "between the 110 and 120 fathoms level, on this "*(Taylor's)* lode, a little west of Taylor's shaft, a very extensive '*vugh*,' or "cavity was discovered; the size was much greater than is commonly observed, "being nearly forty fathoms in length, and from one to two fathoms high; the "direction was nearly horizontal, the lode both above and below producing "good ore." Mr. Burr, *Mining Review*, No. vii. (July, 1835), p. 47.

See also Mr. De la Beche, Report, p. 324.

4 *Ante*, pp. 174-185-204.

ingredients. When the *lode* consists either entirely, or for the most part, of ore, it is provincially called *a course of ore;* and, if the metallic substances appear in short and unconnected masses, they are designated *bunches of ore.*[1] Whatever may be the positions and dimensions of these bodies of ore, they are usually altogether isolated and separated from each other by the earthy minerals of which by far the largest part of every *lode* consists.

It has been already stated that longitudinal joints prevail in those parts of the contents of *lodes*[2] which consist of earthy minerals, of which the characters depend on those of the contiguous rocks,[3] and that *horses of ground* are often contained between different portions or branches of the same *lode.*[4] Akin to these characters are the irregular and unconnected masses which, sometimes of metallic and sometimes of earthy minerals, are imbedded in certain parts of some *lodes,* and give them a brecciated structure.[5]

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[1] Mr. Burr, Mining Review, No. viii. (May, 1836), p. 218: Mr. De la Beche, Report, pp. 325–327.

[2] *Ante,* p. 180. [3] Ibid, p. 184. [4] Ibid, p. 176.

[5] "The layer of felspathic rock, which is worked for tin ore near the Indian "Queens, so abounds in small angular portions of different colours and texture, "that it resembles a coarse *lime-ash floor:* this rock appears to be a regular "*elvan-course,* equivalent to the beds of porphyry which are associated with "the Cornish slates. * * * And it is indeed worthy of observation that the "contents of the Cornish veins are commonly arranged in a brecciated manner "consisting of quartz and of angular pieces of the adjacent rock, whilst the "conglomerated structure is of rare occurrence."

DR. BOASE, *Primary Geology,* p. 116.

"Portions of the surrounding rocks are also occasionally imbedded in the "veinstone, which then sometimes assumes a conglomerate character."

MR. BURR, *Mining Review,* No. viii. (May, 1836), p. 220.

"Among the examples of brecciated lodes observed during the Survey may "be noticed—Fragments of slate cemented by quartz and yellow copper ore "from the principal lode at Consols mines, Gwennap; angular portions of

In this form wood-tin occurs at the *Garth Mine*,[1] and copper pyrites at *Trevaskus* and in almost innumerable other localities. The earthy minerals thus enclosed have however attracted most attention. These, in some instances, appear like short vein-shaped masses; in others, as angular lumps irregularly distributed through the *lode*. Occasionally they are sharply-defined, apparently by lines of symmetrical structure; whilst, frequently, they seem to be connected by almost imperceptible transitions with the other ingredients of the *lodes*. When they consist of schistose slaty matter their planes of lamination often coincide with those of the containing rock, but this is not always the case; if they are of *elvan*, or granite, the resemblance to the other components of the *lodes* is so close that their relations cannot be well ascertained. Whatever may be the nature of the *Country*, these enclosed masses invariably resemble the contiguous rock; as, for instance, at *Binner Downs*, which is in slate, the *South lode* is for some distance almost entirely composed of thin alternating plates of slate and quartz, each occasionally intersecting the other, and both alike frequently penetrated by short irregular and unconnected veins of chlorite.

In general these included portions of rock are extremely small, and only in this respect differ from

" slate cemented by yellow copper ore at the United mines, Gwennap; frag-
" ments of slates united by yellow copper ore and quartz, Wheal Trenwith,
" St. Ives; fragments of slate cemented by oxide of tin and yellow copper ore,
" Wheal Fortune, near Marazion," &c., &c. MR. DE LA BECHE, *Report*, p. 323.
Mr. R. W. Fox, Report Royal Corn. Polytech. Soc. (1836), pp. 87–108–124.

[1] Mr. Carne, Cornwall Geo. Trans. iv. p. 99.

the *horses*.[1] In the latter, the *lodes* and *branches* are but small when compared with the *horses* enclosed between them, as at *Wheal Reeth, Dolcoath, Cook's-kitchen, Wheal Music, Carclaze*, &c.; whilst, in the former, the included parts bear no proportion to the *lodes* in which they are contained. Between them there is, however, a regular gradation in size, and the only distinction, if indeed it can be called one, is that the smaller are enclosed in one vein, whilst the larger are included between two, which are still, in fact, but parts of the same *lode*.

This brecciated structure may be seen in granite at *Balleswidden, The Bunny*, and *Carclaze*; in *elvan* at *The Wherry, Parbola, Dolcoath, Polgooth*, &c.; and in slate at *Rospeath, Binner Downs, Duffield*, and *Wheal Towan*, and indeed in localities too numerous to be mentioned: and in some the whole *Country*, for considerable distances, seems to consist of minute metalliferous veins enclosing small pieces of rock between them.[2]

When a *lode*, composed of soft or disintegrated substances, comes in contact with a very hard rock, for example, with a quartzose slate, as at *Wheal Friendship, elvan* at *Dolcoath* and *Polgooth*, or fine grained granite, as in the western parts of *Tincroft*

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[1] *Ante*, p. 176.

[2] "In all the crystalline granitoid rocks of Cornwall there are also many "masses and '*veins of segregation*.' Such are the great contemporaneous "masses and veins of schorl rock; and some of these are metalliferous. The "decomposing granite of St. Austell Moor is traversed, and sometimes entirely "superseded, by innumerable veins of this description." PROF. SEDGWICK, *Address to Geo. Soc.* (1831), *Proceedings of Geo. Soc.*, i. p. 283; *Phil. Mag. and Annals* (1831), ix. p. 284.

Consols, and *Wheal Reeth,* it is often split into strings: perhaps, however, it may be said with more accuracy that the whole rock assumes a veined structure. And further, when a *lode* becomes very large it often contains *horses* of the contiguous rock; and this seems to be most prevalent when iron pyrites is its chief ingredient, though it sometimes takes place when copper pyrites abounds.

The mixed, compound, and complicated composition which prevails in the earthy minerals found in *lodes,* extends to their metallic contents also.

Thus, tin ore is found mixed with, and interspersed through the following metallic minerals in the most irregular manner: viz., native copper at *Boscaswell Downs;* copper pyrites[1] at *Saint Ives Consols, Wheal Darlington, Tincroft, Wheal Friendship,* &c., and in the state of a double sulphuret, which has been called tin pyrites, at *West Pink,* and *Botallack;*[2] vitreous copper ore in *Botallack, Levant,* and most of the mines in Saint Just; earthy black copper ore in *Wheal Jewel;* blende at *Ball-due,* and *Wheal Budnick,* and in the last-mentioned mine with vitreous copper ore, copper pyrites, and galena, also; with native bismuth in *Botallack,* and *Levant;* sulphuret of bismuth in *Balleswidden,* and with the carbonate of the same metal at *Levant;* with crys-

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[1] Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 127: Mr. Carne, Cornw. Geo. Trans., ii. pp. 94–104: Mr. Burr, Mining Review, No. viii. (May, 1836), p. 223: My own Paper, Edin. New Phil. Journal, xxii. p. 271: Mr. R. W. Fox, Report of the Royal Cornwall Polytech. Soc. (1836), p. 85: Mr. De la Beche, Report, p. 327.

[2] Dr. Boase, Cornwall Geo. Trans., ii. p. 384.

tallized phosphate of iron at *Wheal Kind*,[1] and with the same metal, in an earthy state, at *Park-noweth*.

Vitreous copper ore has been found mixed with native copper at *Levant*, *Providence Mines*, *Ting Tang*, &c.; with red oxide of copper at *Wheal Gorland*, *Penstruthal*, and *Wheal Charlotte*; mixed with and investing copper pyrites at *Wheal Buller*, *Cairn Brea Mines*, *Wheal Jewel*, and, more or less, in most of the mines in which copper ores are abundant;[2] with the blue and green carbonates of copper at *Wheal Buller*, *Ting Tang*, and *Gunnis Lake*; with crysocolla and the arseniates of copper at *Ting Tang*; with pitch-blende at *Wheal Edward*, and *Wheal Trenwith*; and with uranite at *Wheal Edward*, *Wheal Buller*, and *Carharrack*.

In the *vughs*, which are numerous, in the copper pyrites at *Fowey Consols*, crystals of the sulphuret of bismuth are plentiful; mineral pitch occurs in similar situations at *North Roskear*, *East Wheal Crofty*, *South Wheal Towan*, *East Wheal Damsel*, and *Treskerby*;[3] and at *Wheal Falmouth* the crystallized phosphate of iron, the carbonate and phosphate of lead, and buntkupfererz were found under the same conditions.

The most abundant of the metallic minerals afforded by the *lodes*, are, however, iron and copper pyrites,[4] and these are found in various forms, and mixed in every possible proportion.

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[1] Near Saint Agnes Beacon. [2] Locally called *coated ore*.
[3] Mr. Carne, Cornw. Geo. Trans., ii. p. 104.
[4] Mr. R. W. Fox, Report of the Royal Cornw. Polytech. Soc. (1836), p. 86.

			Herland.
			Wheal Brothers.
			Dolcoath.
			All copper mines.
	Vitreous copper ore		Wheal Speed (Germoe).
	Capillary red oxide of copper		Providence Mines.
			Wheal Falmouth.
			All copper mines.
	Sulphuret of bismuth		Fowey Consols.
	Fluor		Polberrow
			Almost all copper mines.
	Galena	*Quartz*	Wheal Rose.
	Blue lead ore		Wheal Hope.
	Pearl spar		Union Mines.
	Fluor		West Pink.
	Blende		Union Mines.
			South Wheal Towan.
			Most tin mines in clay slate.
			Cann Quarry.
			Wheal Unity Wood.
			Wherry Mine.
			Wheal Coates.
ore	*Blue carbonate of copper*		Ting Tang.
	Malachite		———
			———
			Wheal Buller.
			Ting Tang.
			———
			———
			———

The usual accompaniments, both of tin ore and of copper pyrites, seem to be the metallic sulphurets; the oxides, and salts of the various metals seldom occur in their immediate vicinities.

The task would be endless to enumerate the minerals afforded by the *lodes*, and the localities from which they have been obtained; I have, therefore, attempted to reduce the order of position to a tabular form (Table C). The first column denotes the *Country*, the second the substance next the side or *wall* of the *lode*, the next that which is attached to it, and so on; and I have distinguished the crystallized minerals by an Italic letter, and the massive ones by a Roman. The localities are pointed out by foot-notes.

As the present Table is a first attempt, I doubt not it will be found susceptible of many improvements. I shall abstain from drawing inferences of my own, though many are obvious enough.

With the exception of *Herland*, already noticed,[1] the *lodes*, in almost every district, are productive on similar lines taken at right angles to their bearings;[2] hence the proverbial phrase of "ore against ore."[3] But as the directions of the *lodes* vary in different districts, the directions of these productive lines are not always the same. At *Wheal Edward*, *Botallack*, *Wheal Cock*, and *Levant*, the *lodes* are nearly N. and S., and the bearing of this line is not far from E. and W.; in *Saint Ives Consols*, *Balnoon*, *Wheal Reeth*,

[1] *Ante*, p. 41. [2] Ibid, p. 87.* [3] Mr. Carne, Corn. Geo. Trans., iii. p. 78.

and *Wheal Mary*, it is nearly N. and S., and as the general direction of the *lodes* in this and in the other districts is not far from the magnetic E. and W. (25° S. of W.), the productive lines in various places lie nearly on the magnetic meridian. Thus, in the Gwinear and Helston districts, *Wheal Providence*, *Binner Downs*, *Wheal Strawberry*, *Godolphin*, and *Wheal Vor* are nearly on the same line; in the Camborne district, *North* and *South Roskear* and *Dolcoath* are similarly situated, and *East Wheal Crofty*, *Cook's-kitchen*, and *Tincroft* are much the same; in the Gwennap tract, *Wheal Tolgus*, *Wheal Buller*, and *Penstruthal* exhibit like relations, and *North Downs*, *Treskerby*, *Wheal Chance*, and *Chacewater Mine* stand in a similar position with regard to *Wheal Unity Wood*, *Wheal Unity*, *Poldice*, and *Wheal Gorland*, and these again in respect of *The Consolidated Mines*, *Wheal Jewel*, and *Wheal Damsel*, and, on the south of these, *The United Mines*, *Wheal Squire*, and *Ting Tang* are on the same meridian. A similar arrangement of the ores, in the *lodes* of *Wheal Towan*, *South Towan*, *United Hills*, *Wheal Charles*, *Wheal Music*, and *Wheal Basset*, in the Saint Agnes district; and between those in *Crinnis*, *Pembroke*, and *East Crennis*, in the Saint Austell tract, seems to prevail.

In the other districts the mining operations are so scattered, that it is not easy to discover whether this relation subsists or not.

In speaking of the Redruth and Gwennap district it has been already remarked that there is a gradual

increase in the depth of the workings as we proceed from N. to S.;[1] this observation is also, in a great measure, applicable to lines drawn in the same direction in other places. Thus, on a line from *Saint Ives Consols*, through *Balnoon* and *Wheal Reeth*, there is an increase of depth towards the south; from *Herland*, through *Wheal Providence*, *Binner Downs*, *Wheal Strawberry*, *Godolphin*, and *Polladras Downs*, to *Wheal Vor*, the same takes place; from *North Roskear*, through *South Roskear*, to *Dolcoath*, is another such line; from *East Wheal Crofty*, to *Cook's-kitchen* and *Tincroft*, another; from *Wheal Towan*, through *South Towan*, *United Hills*, *Wheal Charles*, *Cardrew Downs*, *North Downs*, *Treskerby*, *Wheal Chance*, *Chacewater Mine*, and through the parallel *lodes* of *Poldice*, *Wheal Unity*, *Wheal Unity Wood*, and *Wheal Gorland*, to *The Consolidated* and *United Mines*, *East Wheal Damsel*, *Wheal Jewel*, *Wheal Squire*, and *Ting Tang*, and as far southward as *Tresavean*, there is another similar line, on which the mines are worked to much greater depths on the south than on the north.

This seems not to depend on the presence of any particular rock, or any dip of the beds, or on the cleavage-planes of the slate; for the *Herland* and *Wheal Vor* section cuts through granite, slate, and *elvan-courses*, and the direction in which the mines increase in depth is rather opposed to the general underlie of the laminæ of the slate. The inclination

[1] *Ante*, p. 87.*

of the *North Roskear* and *Dolcoath* line is similarly opposed to the dip of the slaty cleavage, and to the position of the granite mass; the line which extends from *Wheal Towan* to *Tresavean* also cuts granite, *elvan*, and slates of which the cleavages have almost opposite dips, and yet the same observation is equally applicable.

I do not, however, intend to say that the ores would be found deeper at one than at the other extremity of either of those lines, if they could be wholly uncovered; but merely to state the fact that they have been followed and profitably worked to greater depths on the south than they have been on the north.

I have already alluded to the positions of the *bunches* or *shoots* of ore in the *lodes*, and which everywhere dip towards the principal body of the slate.[1]

In the same productive lines some of the *lodes* yield the ores of tin, others those of copper, whilst many of them contain both: thus, the *lodes* of *Herland*, *Wheal Providence*, and *Binner Downs*, afford copper ores only; whilst, on the same line, *Polladras Downs* and *Wheal Vor* have produced tin ores alone, and both tin and copper ores occur in *Godolphin*. *North* and *South Roskear* yield copper ores; whilst both tin and copper occur at *Dolcoath*: *East Wheal Crofty* yields no tin ore; but, on the same line, *Cook's-kitchen* and *Tincroft* afford it in abundance. At *Wheal Unity Wood*, *Poldice*, some

[1] *Ante*, p. 194.

parts of *North Downs, Wheal Jewel,* and *The Consolidated* and *United Mines* tin ores are found mixed with those of copper; but, in the other mines on the same productive meridian, copper ores alone occur.

Thus, on the same lines, different *lodes* are prolific of various ores.

4. *On the phenomena which affect the metallic portions of lodes.*—In different districts the miners are accustomed to form different expectations from the presence of certain characters, and those which in one are thought very favourable, in another are considered most unpromising. In general, however, this difference is confined to minor shades easily recognized by the eye, though to describe them will, I fear, prove a difficult task, especially as the present is the first attempt which has been made to collect the conclusions to be drawn from experience.

It has been remarked by every writer[1] that almost the whole mineral wealth of this, our most valuable, County, occurs within a distance of two or three miles on each side of the line of junction of the slate and granite. This is unquestionably true; yet no part of the line itself seems to have been more productive than any other spot of equal extent

[1] M. Jars, Voyages Métallurgiques (1765), iii. p. 191: Dr. Berger, Geo. Trans., o.s. i. p. 165: Mr. William Phillips, Geo. Trans., o.s. ii. p. 132: Mr. Carne, Corn. Geo. Trans., ii. p. 103; Mr. Burr, Mining Review, No. viii. p. 244, x. p. 181: Prof. Phillips, Ency. Metrop., *Geology,* p. 777; Ency. Brit. (re-publication), p. 275; Lardner's Cab. Cyclo. No. cxi. p. 125: Prof. Sedgwick, Address to the Geo. Soc. (1831), Proceedings of the Geo. Soc. i. p. 283: Mr. R. W. Fox, Report of the Royal Cornwall Polytech. Soc. (1836), p. 82: Mr. De la Beche, Theoretical Geology, p. 219; Report, p. 327.

within the distance already mentioned: and, though the *lodes* not uncommonly run for several fathoms with granite on one side and slate on the other, or with either of these rocks forming one *wall*, and *elvan* the opposite one, yet the portions so contained between dissimilar rocks are not generally the richest. Examples of this occur at *Little Bounds, Providence Mines, Wheal Vor, Wheal Trannack, Dolcoath, Cook's-kitchen, Tincroft, Wheal Buller, Tresavean, Herland, Ting Tang, The Consolidated Mines*, &c.

But the metallic contents of the *lodes* are affected, not only by the mineral composition of the contiguous rocks, but by their mechanical structure and positions also.

(*a.*) *Mineral composition of the rocks.*—Whether the rocks be granite, slate, or *elvan*, their hardest portions are always quartzose, and in these the *lodes* are seldom rich;[1] this may be, either because a hard rock is unsuited to the presence of metallic minerals, or because the *lodes*, when traversing this quartzy rock, partake of its nature, and thus afford no place for the reception of other substances of greater value. But, whatever may be the cause, the fact at least is well ascertained.

In granite, a fine grained rock *(whet-stone)* is always an unfavourable indication, as in the western parts of *Wheal Reeth, Tincroft Consols*, and *Wheal Mary;* and if that which is of a coarser texture, contain large, white, and sharply-defined crystals of felspar, it is equally so.

[1] Mr. Burr, Mining Review, No. x. p. 184: Mr. De la Beche, Report, p. 363.

On the other hand, if the rock be neither very fine nor particularly coarse grained, the imbedded crystals of felspar of a greenish, pink, or brown hue, and their bounding-planes rather indeterminate, or passing gradually into the basis of the rock, and if, further, that basis consist of greenish felspar beside the other usual ingredients, viz. quartz, mica, and sometimes schorl, the character of the rock is considered a very favourable one; and from the *lodes* in it there are fair expectations, especially of obtaining tin ore.

In *elvan,* the hard fine grained quartzose varieties, which also generally contain some schorl, often diffused as a colouring matter and sometimes in groups of radiating crystals, are considered uncongenial; as the *lodes* are frequently split into innumerable irregular and small veins, whilst they traverse that kind of *elvan,* but which re-unite when they approach softer and more felspathic varieties of the same rock, as at *Dolcoath* and *Polgooth.*

The varieties of *elvan* usually most favourable to riches in the *lodes* differ slightly as regards tin and copper ores. In the former they are sometimes tolerably productive, even when split into strings, in glassy quartzose *elvan;* whilst, in the latter, unless the rock be soft and somewhat inclined to decomposition, the *lodes* split, dwindle, and become unproductive.

The slate in the neighbourhood of the Saint Just and Saint Ives copper mines is a greenstone slate,[1]

[1] Dr. Forbes, Cornw. Geo. Trans., ii. p. 257: Mr. Carne, Ibid, p. 318.

in general tolerably fine grained and lamellar; a massive rock, of somewhat similar composition, occurs in some parts of *Dolcoath* and *Cook's-kitchen*, and in *East Wheal Crofty*,[1] and *North Roskear*. In all these spots both tin and copper ore occur, excepting the two last, which yield copper ore only. The axinite, actynolite, and garnet rocks, which are associated with the greenstones, do not seem favourable to the presence of metallic substances in the *lodes* which traverse them. At *Wheal Trannack*, *Dolcoath*, *Cook's-kitchen*, *Cairn Brea Mines*, and, in general, around the skirts of the granite of Cairn Brea and Cairn Marth (except on the eastern side of the latter), a thickly lamellar brownish-purple slate rock[2] is traversed by the *lodes*; all of which contain copper, and most of them tin ores also.

A clay slate, of a very pale greyish hue, passing into a dull white, and here and there marked between the laminæ with a few bluish spots, which, in short, is not altogether unlike a thick-bedded porphyry with internal traces of a lamellar structure, but in a state of decomposition, accompanies the richer portions of the copper *lodes* at *Ting Tang*, *Wheal Virgin (Consolidated Mines)*, *Wheal Jewel*, *Wheal Unity*, and by far the greater portion of the Gwennap district; at *Wheal Music*, *Wheal Basset*, *Wheal Charles*, the western part of *Wheal Towan*, *Great Saint George*, *Wheal Leisure*, and the greater part

[1] I have found a massive rock, composed of hornblende and felspar, on the north of this mine, traversed by numerous small veins of calcareous spar.

[2] Prof. Sedgwick, Camb. Phil. Trans., i. p. 133: Dr. Boase, Cornw. Geo. Trans., iv. p. 312; Primary Geology, p. 39.

of the neighbourhood of Saint Agnes; at *Pembroke*, and some of the Saint Austell tract; and in *Redmoor*, and some portions of the Callington district. In all these tin ore is very scarce, although found in small quantities in the shallower parts of some of them. Notwithstanding, copper ores have been plentiful in the same *lodes* after they quit this pale-tinted slate and enter that of a deep blue colour, which is also generally quartzose;[1] as at *Wheal Fortune (Consolidated Mines)*, and *Ale and Cakes (United Mines)*: yet, in the far greater number of instances, the riches either dwindle or suddenly disappear with this change of *Country;* as at *Wheal Virgin (Consolidated Mines)*, and in the deeper parts of *Great Saint George, Wheal Leisure*, and *Wheal Towan*. In some parts of Gwennap a reddish slate is considered equally unfavourable to the produce of the *lodes* by which it is intersected.[1]

At *The Marazion Mines, Wheal Darlington, Great Wheal Fortune*, and other parts of the Marazion district; at *Herland, Binner Downs, Godolphin*, and most of the neighbourhood of Gwinear and Crowan; in the eastern parts of *The Consolidated* and *United Mines;* in the eastern part of *Wheal Towan*, at *South Wheal Towan, Wheal Prudence*, and some other portions of the Saint Agnes tract; in *East Crennis, Fowey Consols*, and the vicinity of Saint Austell; and at *Wheal Franco, Wheal Friendship*, and, in general, through the Tavistock district,

[1] Mr. Carne, Cornwall Geo. Trans., iii. p. 81: Mr. Burr, Mining Review, No. x. (1837), p. 185: Mr. De la Beche, Report, p. 337.

copper ores, chiefly pyrites, are found in a deep blue clay slate, homogeneous in texture, of a glossy and silky lustre, having a very even lamination, and opening in thick horizontal joints which coincide with the cleavage-planes. In this rock the *lodes* seldom contain tin ore. If the slate assume a deeper hue, the copper ores which the *lodes* may have previously yielded are replaced by iron pyrites;[1] and, if the rock become quartzose, even the iron pyrites disappears.

The slate in the vicinity of *Wheal Vor, Cook's-kitchen, Tincroft, Poldice, Polberrow, Polgooth, Drake Walls,* and indeed wherever tin ore abounds, is of a tolerably uniform character, namely thick-bedded deep blue, which here and there has a somewhat greenish tinge, and rather a greasiness or gloss on the surface of the cleavage-planes, as if it had been wetted: at other times there is a little difference in the colour of the laminæ, and something of a quartzose aspect in many parts.

A diminution in the depth of the colouring, and a softening in the texture of the rock, is mostly an unfavourable omen.

The few *lodes* which afford lead ore occur in the blue and greyish varieties of the slates, and generally at great distances from the granite.

(*b.*) *The mechanical structure of the rocks.*— Whether the rock be granite, slate, or *elvan*, when the joints which are parallel to the *lodes* in their

[1] Mr. Carne, Cornwall Geo. Trans., iii. p. 82.

directions fall towards the *lodes* in descending, it is considered a favourable indication; whilst, if similar joints separate from them as they go downward, it is considered an index of poverty. In all these cases, many transverse joints seem to exercise an unfavourable influence on the produce of the *lodes;* and often a vein *(course)* of ore is directly and immediately cut off by a joint running across the *lode.*

Both in granite, and *elvan,* a well-defined porphyritic structure is a most unpromising character; whilst a gradual blending of the included crystals with the basis of the rock, is, in both cases, considered an encouraging appearance.

The cleavage-planes of the schistose slates are almost invariably curved and contorted whenever the rock is quartzose, and in such cases it is usually very fissile,[1] and the laminæ are highly inclined: either of these conditions is accounted inauspicious. On the other hand, when the cleavage-planes are regular, and moderately inclined, and when the rock exhibits a thickly lamellar structure, the *lodes* which traverse it may be expected to be productive. The fissile slates are also frequently very hard; whilst the thick-bedded varieties are generally much softer.[2]

Yet all these appearances, whether *kindly*[3] or unfavourable, are but local, and are often confined within very narrow limits, and in the same rock

1 Mr. Carne, Cornwall Geo. Trans., iii. p. 82.

2 Mr. Burr, Mining Review, No. x. (1837), p. 185: Mr. De la Beche, Report, p. 336.

3 The terms *kindly* and *unkindly* are locally used to denote favourable and unfavourable appearances in the *lodes.*

there is frequently an alteration in the *lodes* as soon as the characters of the rock are changed.

(*c.*) *Mineral composition of the lodes.*—I have before noticed the occurrence of earthy brown iron ore *(gossan)* in the superficial portions of *lodes*,[1] and that they generally contain tin ore: their appearance, however, depends on the ore with which they abound. The copper *gossans* are generally softer, paler, less quartzose, or rather perhaps the quartz in them is oftener friable, and they are more vesicular than the tin *gossans* are. But sometimes there is no *gossan* near the surface, and the shallower portions of the *lodes* are then frequently mere quartzose varieties of the contiguous rock;—schorlaceous if tin ore abounds, and containing spots of iron and copper pyrites, and of earthy black copper ore, if they are chiefly productive of copper ores. A very soft, or very hard *gossan,* is equally thought less favourable, than if its consistency be moderately firm, and a very dark colour is also a discouraging symptom.

In granite, the *lodes* which are chiefly productive of tin ore, are for the most part composed of a pale greenish felspar of a confusedly crystalline structure, but seldom containing distinct crystals, with radiating groups of schorl, and some quartz. Through this compound substance the tin ore is interspersed in the form of crystalline granules, which are seldom as large as a pea; more commonly it is almost impalpable, or small as sand;—but still generally

[1] *Ante*, p. 204.

crystallized. In a few cases, as at *Great Work* and *Trevidgia*, the *lode* is very quartzose, and then the particles of tin ore are usually larger. Now and then there are small veins of tin ore almost pure, or but slightly sprinkled with quartz, schorl, and felspar, but this happens more frequently when these minute veins only traverse the rock, without any other vein-stone or matrix, as at *Balleswidden, Carclaze*, &c.

Occasionally the *lodes* consist almost wholly of quartz, with now and then some schorl diffused through it as a colouring matter; in such cases they are seldom rich in ore of any kind.

The *lodes* which yield copper ore in granite almost always contain *gossan* near the surface; and, as already noticed,[1] it usually continues to somewhat greater depths than it does in slate; as at *Tresavean, Ting Tang*, &c. Their quartz is not always so soft *(sugary)* or so minutely divided as in slate, but opens in small irregular masses which yield to a small pressure: a coating of earthy brown iron ore appears to pervade the small and innumerable cavities which penetrate this slightly coherent mass. Large quantities of decomposed felspar abound, and the whole is often smeared with a thin and almost impalpable coating of earthy black copper ore: the proportion of this last-mentioned substance often increases in depth, and passes into vitreous copper ore, as at *Levant;* and sometimes into copper pyrites, as at *Tresavean.*

[1] *Ante*, p. 206.

When the *lodes* are very granitic, or when they contain much of the schorlaceous quartz, already mentioned, they are seldom productive: indeed copper ores are rarely found imbedded in schorl.

In slate, the composition of the tin *lodes* is generally of a very hard quartzose slate *(capel)*;[1] sometimes thoroughly mixed with schorl, occasionally with felspar, and frequently with chlorite. The tin ore is interspersed amongst the earthy materials even more minutely than it is in the granite, and it is almost invariably mixed with a much larger proportion of impurities which injure the quality of the metal produced from it. Wolfram,[2] with earthy red and jaspery iron ores, are often associated with tin ore, as at *Poldice, Kit Hill,* &c. The most characteristic mineral is, however, a variety of schorl rock, consisting of alternating layers of schorl and felspar, and both of these mixed with quartz:[3] the laminæ are almost always much curved, as at *Poldory, Wheal Vor,* &c., and sometimes the layers of schorl are replaced by tin ore, as at *Fat-work Mine,* near Indian Queens.[4] This substance usually forms a kind of transition between the *lode* and the *Country.*

The *lodes* which yield copper ores in slate have been already said to contain large quantities of earthy brown iron ore *(gossan)* of a pale hue, soft, and *drusy.* In them also tin ore frequently occurs in

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[2] *Caply* or *Scovan lodes* more frequently yield tin than copper ores.

[1] Provincially called *Cal* or *Callan.* Tungstate of lime is mixed with tin ore at *Wheal Friendship.*

[3] *Ante,* p. 152. [4] Dr. Boase, Cornw. Geo. Trans., iv. p. 252.

small quantities, and blende is very plentiful, but iron pyrites is almost constantly present. Their earthy minerals are mostly quartz, which in the most favourable situations is generally friable *(sugary spar)*,[1] sometimes mixed with small quantities of decomposed felspar *(prian)*.[2] Near the surface these are spotted with earthy black copper ore, and lower down this is succeeded by vitreous copper ore, and at length by copper pyrites: fluor is occasionally mixed with them, as at *Wheal Gorland, Wheal Unity Wood, Wheal Devonshire,* &c.; and now and then chlorite occurs, as at *Wheal Kayle, Binner Downs,* &c.

In many places, and more especially in the slaty rocks in the neighbourhood of the fossiliferous beds, as at *East Crennis, Fowey Consols, Trevorgus,* near Padstow, and *Treburget,* near Camelford, the *lodes,* when large, consist almost wholly of a very white crystalline quartz, abounding in drusy cavities *(vughs)* lined with crystals of the same, and enclose innumerable disjoined pieces of slate. These masses of slate are in general very sharply defined, present but few traces of transition into the quartz, and are commonly very uniform in their positions: frequently, however, they have a sort of flinty character which obscures any traces of cleavage. The cavities lined with crystals, and the included spots

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1 Mr. Pryce, Mineral. Cornub., p. 92: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 118: Mr. Carne. Cornwall Geo. Trans., ii. p. 101: Mr. R. W. Fox, Report of Royal Cornwall Polytech. Soc. (1836), p. 86.

2 *Prian* now denotes felspar clay; but in Mr. Pryce's time it appears to have denoted a friable nature, whatever might have been the mineral.

of slate, are most unequivocal signs of poverty, wherever they may occur. There are also certain minerals which are seldom found in the richer parts of *lodes:* in those which yield copper ore, chlorite[1] is one of the most conspicuous. The occurrence of tin ore in the deeper parts of *lodes* which have previously produced copper ore only, is accounted a very unfavourable indication.[2]

There is a remarkable difference between the character of the crystallized quartz in the vicinity of the fossiliferous rocks, and that which it bears in the mining districts nearer to the granite: in the former, the *vughs* are very numerous and usually small, and the quartz crystals with which they are incrusted are almost microscopic and of a snowy whiteness; whilst, in the latter, the cavities though generally larger are far less frequent, and the crystals are of greater size, and have in many cases a considerable degree of transparency.

(*d.*) *Structure of the lodes.*—A *lode* which abounds in drusy cavities, allowing the water to pass through them draining the mine for considerable distances, and more particularly when the water so escaping is very warm,[3] is thought well of;[4] and it is also considered a favourable symptom if the *lode* be soft.

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1 Provincially called *peach*. See Mr. Carne, Cornw. Geo. Trans., ii. p. 101: Mr. R. W. Fox, Report of Royal Cornw. Polytech. Soc. (1836), p. 87.

2 Mr. R. W. Fox, Report of Royal Cornwall Polytech. Soc. (1836), p. 85.

3 Mr. Pryce, Mineral. Cornub., p. 12: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 121: Mr. R. W. Fox, Report Royal Corn. Polytech. Soc. (1836), p. 107.

4 I have never been able to prove this by experiment. Some of the warmest streams I have examined have been from very unproductive *lodes*.

But, if the *lode* be soft, whilst the contiguous rock is hard, little must be expected; for in such cases the *lode* usually dwindles to a mere line, or splits into several small *strings:* and, generally, a hard *lode,* whether it be in a soft rock, or indeed in any other, is seldom productive. On the other hand, where both are very soft, the *lodes* are for the most part large, and, under such circumstances as I have already pointed out,[1] they almost always split into *strings,* which commonly consist of iron pyrites, and frequently die away in the *Country:* or become quartzose, and form integral members of the slate series *(Country branches).*[2]

It is a remarkable fact that in every *lode,* whether it yields tin, copper, or lead ores, the portions which are the most perpendicular are always the most productive.[3] This perpendicularity invariably takes place by an alteration in the inclination of the lower or *foot wall* of the *lode,* which becomes more vertical *(bellying out);* whilst the opposite, or *hanging wall,* may continue on the line of its original dip: this change consequently produces, at one and the same time, a more perpendicular appearance, and an enlargement of size in the *lode.*

A crooked course is considered very unfavourable; and, indeed, the majority of *lodes* which are much

[1] *Ante,* p. 224. [2] Ibid, p. 118.

[3] This important general law was first announced by Mr. Thomas, who says "it is generally observed in the variations of the underlay or dip, that those "parts are richest which are nearest to perpendicular." *Report,* p. 20.

My own Paper, Edin. New Phil. Journal, xxii. p. 158: Mr. R. W. Fox, Report of Royal Corn. Polytech. Soc. (1836), p. 87: Mr. Burr, Mining Review, No. x. p. 169: Mr. De la Beche, Report, p. 324.

curved and very irregular in their bearing, are small as well as poor: whilst, on the other hand, a straight *course* is accounted a desirable character.

Those parts of the *lodes* which are traversed by longitudinal joints, as in *Binner Downs*, *Wheal Strawberry*, *Godolphin*, &c.; by cross joints, as in *Trevidgia*, and *Charlestown Mines*; and likewise those portions of them which exhibit traces of an horizontal *bedding*, as at *Duffield*, and *Wheal Friendship*, are generally very poor and unproductive: still some of the richest vitreous copper ore in *Levant* has a sort of lamellar arrangement.

(*e.*) *On the effects which are produced on the contents of lodes by their interference with each other.*— It has been already stated that when the structural planes of the rocks in descending fall into a *lode*, it is considered a favourable indication. The same holds good of veins, *branches (feeders)*[1] uniting with a *lode* as they go deeper; and by some the chances of improvement are thought the greater, the smaller the angle included between the veins thus uniting.[2] As the separation of the joints from *lodes* on the line of their underlie is accounted an unfavourable symptom; so also is it one of approaching poverty when veins *(droppers)*[3] fall off from *lodes* in like manner.

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[1] Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 138: Mr. R. W. Fox, Report of the Royal Corn. Polytech. Soc. (1836), p. 83: Prof. Phillips, Lardner's Cabinet Cyclo., No. cxi. p. 130.

[2] Mr. Pryce, Mineral. Cornub., p. 103: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 115: Mr. Carne, Corn. Geo. Trans., ii. p. 100: Mr. R. W. Fox, Report of the Royal Corn. Polytech. Soc. (1836), p. 87: Mr. Burr, Mining Review, No. x. p. 176: Mr. De la Beche, Report, p. 333.

[3] Mr. Thomas, Report, p. 20: Mr. Carne, Corn. Geo. Trans., ii. p. 101.

Very numerous examples of the richness of parallel *lodes*, on the same meridian, have been already quoted.[1] This fact is now believed to be most valuable and important: and even the corresponding parts of other veins, parallel to those which have been rich, have been thought more likely to be productive than other parts of the rich *lodes* themselves, which for a very long time were supposed to afford the best chances of success.[2]

Not a few of the larger and richer *bunches*, both of tin and of copper ores, have occurred in the immediate vicinity of *cross-courses* and *flucans*;[3] and frequently has the produce been exclusively found on one side of these intersections,[4] whilst on the opposite side the same *lode* has been entirely worthless; as at *Wheal Friendship, Wheal Jewel, Wheal Vor* near *Woolf's cross-course*, beside innumerable other instances.

It has been already stated that an eminent authority[5] gives it as a general law in the Gwennap district, that a *lode* is seldom or never rich after it has passed through an *elvan-course* in descending.

The surfaces of many of the most productive mines are intersected by depressions;[6] sometimes of but limited dimensions, as at *Wheal Alfred, Wheal Vor, Poldice*, &c.; though frequently by small but deep ravines, as at *Herland, Dolcoath, Wheal Tolgus, Wheal Towan, Wheal Leisure, Polgooth, Wheal*

[1] *Ante*, p. 215. [2] Mr. Carne, Corn. Geo. Trans., iii. p. 76.
[3] Mr. Carne, Corn. Geo. Trans., ii. p. 99: Mr Burr, Mining Rev., No. x. p. 178.
[4] Mr. Carne, Cornwall Geo. Trans. ii. p. 99.
[5] Mr. M. Williams, *ante*, p. 91, note. [6] Mr. Burr, Min. Rev., No. x. p. 191.

Franco, Wheal Friendship, &c. The directions of these glens sometimes coincide with those of the *lodes,* as at *Godolphin, The Consolidated Mines, East Crennis,* &c.; but they rather more commonly form considerable but varying angles, as in *Herland, Dlocoath, Wheal Tolgus, Wheal Towan, Wheal Leisure, Wheal Friendship,* &c.

Whether the origin of these small valleys[1] may be due to the softer texture of rocks in the vicinity of rich *lodes,* as the *water-shed* of the country on either hand is nearly at right angles to the general bearing of the *lodes,* they may have been thus more exposed to the erosive action of diluvial currents, is foreign to the object of this enquiry.

As, therefore, the productiveness of *lodes* depends on so many conditions, both in the mechanical structure and mineral composition of the rocks, as well as of the *lodes* themselves; and as experience seems to show that the same characters assume a different value in different districts; it is evident that the difficulty of forming an opinion on the probability of success in mining is very great.

It must be confessed that neither theory, nor practical knowledge forms any very certain ground, in the present state of this branch of science. A more extended experience, and a more careful generalization of facts seem to afford the only remedy. But when the vast variety of ever-changing circumstances is considered, we can only hope that our conjectures will at length attain a greater probability,

[1] Mr. Hawkins, Corn. Geo. Trans., iii. p. 7: Dr. Boase, Ibid, iv. p. 434.

and that if they fail of absolute certainty, they will, at least, lead to a closer approximation to the truth.

5. But metallic minerals, though much more abundant in the *lodes* than in any other mode of distribution, are also diffused throughout the rocks, in irregular masses, and in minute veins.

(*a.*) *The diffusion of metallic minerals through the rocks.*—Small crystalline granules of tin ore are dispersed through and form an integral part of the granite of *Balleswidden*,[1] Raggy-rowal,[2] *Wheal Vyvyan, Carclaze,* Kit Hill, &c.; of some portions of the *elvan-courses* at *The Wherry, Parbola, Relistian, Wheal Vor, Wheal Unity Wood,*[3] and *Polberrow;* and of the slate at *Fat-work.* Copper pyrites also forms an ingredient in the granite at *Wheal Vyvyan,* and in the slate at *Wheal Music.* The ore is disseminated through the rock in just the same manner as it is in the *lodes,* except that it is more thinly sprinkled. On this account, indeed, but for the opportune occurrence of streams, which furnish a cheap mode of working, *Wheal Vyvyan* and *Carclaze* would probably remain unwrought. The metalliferous *Country* of the other mines I have

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1 It is customary, in almost every part of the County, to cut up the sod, as well as the heath and furze growing on the *downs*, for the purposes of fuel. An examination of the turf taken up at *Balleswidden* has brought to light the remarkable fact that it contains tin ore;—a most striking proof of its universal diffusion through coarse soil, as well as the rock of that neighbourhood.

2 Sufficient water for working this spot is only to be collected in winter: it is now so poor as to be scarcely worth pursuit.

3 At *Wheal Unity Wood* (Table lxvi.) both the *elvan-courses* are so rich in tin ore, that they are worked as (and sometimes called) *lodes.*

mentioned is worked by the same power which is applied to other richer, and more usual deposits.

The congeries or segregation of these specks of ore, when they are not formed on lines of regular bearing, form the nodules and other irregular and unconnected masses dispersed through the rock:—as of tin ore in granite at *Balnoon*, and *Saint Ives Consols*; in *elvan* at *The Wherry*, *Parbola*, *Relistian*, and *Wheal Vor*; and in slate at *Fat-work*. On the other hand, when these accumulations take place on regular planes, they form the small veins of tin ore which are found in the stanniferous granite at *Balleswidden (gruys)*, *Carclaze*, and Kit Hill; in *elvan* at *The Wherry*, and *Parbola*; and in slate at *Polberrow*, and *Drake Walls*. Examples of copper pyrites occurring irregularly distributed, and also in the form of minute and regular veins,[1] occur in the granite of *Wheal Vyvyan*, and in the slate of *Wheal Music*.

(*b.*) *The irregular and unconnected masses of ore which are found in the rocks.*—The *lodes*, as they have been called, at *Balnoon*,[2] appear for some extent at the surface with the characters of ordinary *lodes*; such as a prevailing dip and direction, and somewhat regular *walls*; they consist also of green felspar, schorl, tin ore, and the other ingredients usual in tin *lodes*: but they soon reach their limits,

[1] Numerous examples of copper pyrites and vitreous copper ore dispersed in irregular and unconnected masses, and in minute veins through the slate, occur at Taren Belwyd and Cae Mawr, near Dolgelly in North Wales; and I have observed instances of both kinds at the Parys mountain, in Anglesea.

[2] *Ante*, p. 24.

both in length and depth. Sometimes the termination is abrupt, and they abut against the regular granite without any intervention of joints or cross-veins, and re-appear in the same directions within the distance of a few fathoms.

At *Saint Ives Consols*,[1] and, to a small extent, also in *Wheal Speed*,[2] and *Rosewall Hill*,[3] there are masses of metallic minerals which would perhaps in the lead mines of the north be called *pipe-veins*,[4] but here are called *carbonas*.[5] These are bodies of granitic matter, which contain tin ore in precisely the same manner as *lodes* do; but neither appear at the surface, nor extend far downwards. That at *Saint Ives Consols* has been traced about 120 fathoms in length, and in that distance dips 40 fathoms, but it is nowhere more than 10 fathoms either in vertical thickness, or in breadth, and is generally much smaller. It sends off *lode*-like *shoots* or branches laterally, and terminates in the *Standard lode* at its north-west extremity, where it is merely a few inches in height and breadth.

At *Wheal Speed* there are several, but, compared with the last described, they are insignificant in size:[6]

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[1] *Ante*, p. 21. [2] Ibid, p. 187. [3] Ibid, p. 21, note

[4] "A *pipe* vein resembles, in many respects, a huge irregular cavern, pushing "forward into the body of the earth, in a slanting or sloping direction, but "many of them with very different degrees of slope; some of them, having "but a few degrees of slope from the horizontal flatness, and others declining "precipitately, so as to be nearer the perpendicular position than the angle "forty-five. In short, they stand in all positions, between the perpendicular "and horizontal." MR. WESTGARTH FORSTER, *Section of the Strata from Newcastle-upon-Tyne to Cross Fell*, p. 246.

[5] *Ante*, p. 21, note.

[6] As these are so short they appear like pipes: were they of greater extent they would probably be considered *floors*.

these also spring from the *lodes* and have a similar mineral composition. At *Rosewall Hill* too, I am informed they were of no great extent.—All these instances are in granite.

The unconnected masses of tin ore which are found in *elvan* at *The Wherry*, *Relistian*, *Parbola*, *Wheal Vor*, and *Polberrow*, sometimes assuming the appearance of short veins, at others of irregular bodies of some size, and often of small grains disseminated through the whole substance of the *elvan*, but nowhere extending into the contiguous slate, may be considered to belong partly to this class, and partly to that of the stanniferous granite already described.

Somewhat analogous in their characters, but everywhere connected with *lodes*, are the *floors*[1] which strike off from them nearly horizontally. These also consist of the same ingredients as the *lodes*, whether in granite, as at *Botallack* and *Wheal Reeth*, or in slate, as at *Wheal Vor*. The *Trevaunance lode*, at *Polberrow*, which comes in contact with several others, may perhaps be classed with the *floors* as an instance of a more extensive formation of the same kind. All these afford tin ore; but, at *Wheal Trannack* in granite, and *Virtuous Lady* in slate, copper pyrites also occurs under very similar circumstances.

(*c.*) *The minute metalliferous strings and veins*, at *Balleswidden*, *Wheal Vyvyan*, and *Carclaze*, show a

[1] Dr. Borlase, Natural History, p. 161: Mr. Pryce, Mineral. Cornub., p. 81: Mr. Hawkins, Cornwall Geo. Trans., ii. p. 31: Mr. Carne, Ibid, p. 326: M. Fournet, Etudes sur les dépots Métallifères, p. 232: Mr. R. W. Fox, Report of the Royal Corn. Polytech. Soc. (1836), pp. 83-94.

most intimate relation with the stanniferous granite which they traverse; the same connexion subsists between the small veins of tin ore and the *elvan* at *The Wherry* and *Parbola*, which abounds in the same ore, and in both cases they terminate on touching the slate rock on either side of the *elvan;* and a like similarity in character prevails between the containing granite, spotted with copper pyrites and the minute strings of the same mineral at *Wheal Vyvyan*, and in slate at *Wheal Music.*

Whether they are traversing metalliferous rocks, as at *Balleswidden, Wheal Vyvyan, Carclaze*, and *Wheal Music*, or those through which no ores are sprinkled, as at Kit Hill and *Drake Walls*, the rectilinearity of these small veins is equally characteristic, their dips are as well preserved, their intersections by each other and by cross-veins as clearly marked, and their enlargements and contractions, richness and poverty, are as well shown as they are in the large *lodes.*

Their dimensions also vary exceedingly, from a mere line to the size at which they would be everywhere considered as regular *lodes*, and indeed, in all particulars, they have the most exact resemblance—indeed the most perfect identity—with that class of metalliferous deposits. Again, at *Binner Downs, Wheal Trewavas*, and in many other places, there are small veins which are the counterpart of these strings, and separate from and again fall in and reunite with the *lodes.* The *cross-courses* at *Polberrow* intersect and *heave* these minute strings in

exactly the same manner as they do the larger *lodes*. *Pl. XI., Fig.* 1, 2, 3, 4.

Enough has now been adduced to prove that, whether the *Country* be metalliferous or not, in extensive tracts traversed by large *lodes*, or smaller areas intersected by minute strings and veins, the mode in which the metallic minerals are arranged is much the same; viz., that they are aggregated on lines[1] slightly undulating, and generally continuous for considerable distances. When, however, this continuity ceases, the unconnected masses appear to have no dependence on each other, although they may in fact occupy different portions of the same lines.

II.—*The size or breadth of the lodes*

Is the most variable and irregular of their characters.[2] Certain parts of some of them consist of a mere line between the opposing faces *(walls)* of rock, whilst portions of others, as in *Wheal Vor, Tincroft, North Roskear,* &c., are not less than from

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1 "In Cornwall we have, as is well known, both on the great scale and the "small, every modification of veined structure. Tin is distributed through "some of the granitoid rocks where no vein is visible." PROF. SEDGWICK, *Address to the Geological Society* (1831), *Proceedings of the Geo. Soc.* i. p. 283, *Phil. Mag. and Annals*, ix. (1831), p. 283.

2 Dr. Borlase, Natural History, pp. 145–152: Mr. Pryce, Mineral. Cornub. p. 79: Mr. W. Phillips, Geo. Trans., o.s. ii. p. 116: Mr. Thomas, Report, p. 19: Mr. Carne, Corn. Geo. Trans., ii. pp. 88–95–105: Dr. Boase, Ibid. iv. p. 444, and Primary Geology, p. 171: Mr. Taylor, on Mineral Veins, Reports of the British Assoc. (1833), p. 4: Mr. Burr, Mining Review, No. viii. (1836), p. 217: Mr. R. W. Fox, Report of the Royal Cornwall Polytech. Soc. (1836), p. 84: Professor Phillips, Lardner's Cabinet Cyclo. (No. cxi.) *Geology*, ii. p. 129: Mr. De la Beche, Report, p. 343.

30 to 40 feet wide. Such extremes are, however, uncommon in the same *lode*, although its size may still vary considerably, as the following examples will show. At *Tincroft*, some parts of the *Highburrow lode* are but 3 or 4 feet wide, whilst others are 30 or 40 feet; the *Engine lode*, at *(Wheal Crofty) North Roskear*, varies from 1·5 to 18 feet; the *Main lode*, in *Wheal Vor*, varies from 3 to 30 feet in breadth; and the width of the *Bor lode*, in *Polladras Downs*, varies from an inch to 4 feet; at *Polgooth*, *Saint Martin's lode* varies from 1 to 7 fathoms; in *Pembroke*, the variation is from a mere line to 8 feet; and, in *Wheal Friendship*, it is from 2 to 40 feet.

These great changes, though sometimes sudden, are rarely rapid in their progress, and it seldom happens that a very large and a very small portion are found within a few feet or even several fathoms of each other. Every *lode* is generally characterized by a prevailing size, which, however, may now and then greatly fluctuate, though, for the most part, it does so within moderate limits.

On the whole the *lodes* which occur in the granite are smaller than those in the slate, the mean width of the former being 3·18 feet, and of the latter 3·75 feet.

The *lodes*, on passing from one kind of rock into another, frequently change their dimensions, as well as their mineral characters:[1]—thus, at *Great Work*, the *Wheal Breage lode*, in granite, is on an average

[1] *Ante*, p. 189.

about 2 feet wide, but, on entering the slate, it rapidly declines to an inch, and is not again seen to enlarge. In *Wheal Vor*, the *Main lode*, which probably averages not less than from 6 to 8 feet wide in slate, never exceeds 1·5 foot in breadth after it enters the granite in *Carleen*. At *Dolcoath*, the *Main lode* diminishes in size on entering the granite; whilst, in *Tincroft*, where the granite overlies the slate at the *Highburrow lode*, that *lode* was found at least twice as wide in the granite as it was in the slate. In *Ting Tang*, and *Tresavean*, the *lodes* apparently enlarge in granite; on the other hand, at *Wheal Trannack*, *Cook's-kitchen*, *Wheal Buller*, and in some other instances, the passage of the *lodes* from one rock to another is marked by no alteration in their dimensions, although their mineral characters were changed. At *Gwallon* there are some remarkable alterations in the size of the *lode*, although the whole of one *wall* is *elvan*, and of the opposite slate. In *Dolcoath*, the *Caunter lode*; in *Wheal Buller*, *Davey's lode*; at *Poldory*, the *Old lode* and *Buzza's lode*; at *The Consolidated Mines*, *Taylor's lode*; in *Wheal Prudence*, the *North lode*; and at *Polgooth*, *Saint Martin's lode*, assume a veined structure or are split into *strings* on passing from slate into *elvan*; whilst, at *Wheal Darlington*, *Great Wheal Fortune*, *Herland*, *Relistian*, *Duffield*, *Wheal Vor*, some parts of *Dolcoath*, *Cook's-kitchen*, and *Wheal Buller*, no alteration in the size seems to take place, whether the *lodes* be in slate, in *elvan*, or included between both. At *West Poldice*, on the

BREADTH OF THE *LODES* IN THE DIFFERENT DISTRICTS.

Districts.	Tin *Lodes*.				*Lodes* yielding both Tin and Copper.				Copper *Lodes*.				General Average. Feet.
	Less than 100 fms. deep. Feet.	More than 100 fms. deep. Feet.	In Granite. Feet.	In Slate. Feet.	Less than 100 fms. deep. Feet.	More than 100 fms. deep. Feet.	In Granite. Feet.	In Slate. Feet.	Less than 100 fms. deep. Feet.	More than 100 fms. deep. Feet.	In Granite. Feet.	In Slate. Feet.	
Saint Just.....	1·81	1·64	1·86	2·0 *	4·45	..	9·5 *	3·2	2·22	1·62	1·12	1·58	2·23
Saint Ives.....	1·63	1·67	1·55	..	1·76	..	1·35	2·2 *	1·45	0·5 *	1·25	1·22	1·61
Marazion	9·0 *	..	..	9·0 *	5·83	3·16	..	4·42	2·93	..	..	2·93	4·68
Gwinear, &c. ..	..	..	..	..	6·71†	..	..	6·71†	1·5	3·07	..	2·11	2·9
Helston	1·86	3·75	1·18	3·51	3·4	..	4·1 *	2·10*	2·4	..	2·57	..	2·86
Camborne, &c..	..	..	..	..	3·4	4·12	4·03	3.72	3·4	3·3	3·14	3·51	3·68
Redruth, &c. ..	..	..	..	..	..	..	..	..	3·2 ‡	3·5	3·73	3·56	3·36
Saint Agnes ...	1·47*	..	..	1·47*	2·48	7·0 *	..	2·83	3·55	2·45*	..	2·74	3·09
Saint Austell ..	7·21	..	5·19	4·06*	12·4 *	..	..	12·4 *	3·08	2·68	..	3·2	4·79
Tavistock, &c. .	2·0 *	..	..	2·0 *	2·94	..	..	2·94	9·4	6·57*	..	7·0	6·9
Mean..	3·77	2·35	2·44	3·67	4·82	4·76	4·74	4·5	3·31	2·96	2·36	3·09	3·61

* These are from single examples only. † I omit *the hill* at *Trevaskus* from this average.

‡ This does not include the stanniferous *elvans* at *Wheal Unity Wood*.

contrary, the *lode* seemed to increase in size when it was contained between a *wall* of slate on one side and of *elvan* on the other.

As it has been already shown that the *lodes* in granite are somewhat smaller than those in slate,[1] and that tin ore is rather more abundant in the former than in the latter,[2] it might have been inferred that the tin *lodes* were smaller than the copper *lodes:* the difference in this respect is, however, so very trifling, and the results (in *Table* CI.) were in so many instances derived from solitary examples, that but little can be deduced. It is, however, a fact of some consequence, that the *lodes* which yield the ores of both those metals in a state of mixture are considerably larger than those in which either of them is singly found: for whilst the mean size of the tin *lodes* is about 3·06 feet, and of the copper *lodes* 2·93 feet, that of the *lodes* in which both these ores occur is 4·7 feet, and this greater average breadth takes place whatever may be the nature of the containing rock, or the depth at which the mean may have been estimated.

From *Table* CI. it appears that the average breadth of the *lodes*, at less than 100 fathoms deep, is 3·97 feet; whilst, below 100 fathoms, the mean size is but 3·36 feet. In order to explain why this diminution is, in all probability, often only apparent and not real, it is necessary to revert to that portion of the last chapter[3] which treats of the richness of *lodes*. It is there stated that the most productive

[1] *Ante*, p. 241. [2] Ibid, p. 195. [3] Ibid, p. 231.

parts are generally the most perpendicular, and that this erect position takes place by means of the lower *(foot) wall* of the *lode* becoming less inclined *(bellying out)*, and its thus becoming more perpendicular and larger at the same time.

Now, at *Binner Downs, Dolcoath, The Consolidated Mines*, and in many other places, it so happened that the deepest parts were all poor at the periods of my inspection; and, generally speaking, a diminution in the width of a *lode* is a precursor of poverty, whilst an increase in its size is an indication of improvement: therefore the smaller size of the *lodes* just mentioned, together with the flatness in their deepest parts, may be considered not as consequent on the depth, but on their poverty.[1] To the general fact that an increase in size generally attends an improvement in the produce, the large *lodes* which are chiefly composed of iron pyrites are an exception; for these are seldom valuable until they become smaller.[2]

Whatever may be the cause, the general fact of a diminution in the breadth of the deepest parts seems sufficiently evident.[3]

The last column in *Table* CI. gives the mean

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1 "Many mines have been alternately worked and abandoned on reaching "unproductive masses of the vein which at the time were considered a final "termination of its metalliferous portion. * * * * These supposed failures "have often been proved to be partial only."

MR. BURR, *Mining Review*, No. viii. (1836), p. 215.

2 *Ante*, p. 231.

3 Mr. Pryce, Mineral. Cornub., p. 79: Mr. W. Phillips, Geo. Trans., o.s. ii. p. 116: Mr. Carne, Cornwall Geo. Trans., ii. p. 124: Dr. Boase, Primary Geology, p. 171: Mr. R. W. Fox, Phil. Mag. and Annals, vi. (1829), p. 17; Report of the Royal Cornwall Polytech. Soc. (1836), p. 89.

DIP OF THE *LODES*, AND WHETHER TOWARDS OR FROM THE MAIN BODY OF THE NEAREST GRANITE.

Districts.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Perpendicular.	Towards Granite.	From Granite.	Perpendicular & doubtful.
Saint Just	3	10	3	2	21	9	6	..	2	42	11	3
Saint Ives	4	..	..	3	8	1	..	4	2	6	11	5
Marazion	5	..	..	1	7	2	..	..	..	10	3	2
Gwinear, &c.	8	1	..	1	12	6	..	..	..	18	10	1
Helston	13	..	..	..	1	1	1	1	..	10	7	..
Camborne, &c.	26	2	..	3	9	1	..	1	2	13	29	2
Redruth, &c.	24	..	..	2	17	..	..	2	4	24	21	4
Saint Agnes	15	1	1	..	11	..	..	..	2	15	13	2
Saint Austell	13	2	..	..	2	..	3	4	1	17	4	4
Tavistock, &c.	6	..	..	..	2	..	1	..	..	7	2	..
Total....	117	16	4	12	90	20	11	12	13	162	111	28

Table CII.

width of the *lodes* in each district, and exhibits differences in this respect for which it is not easy to assign explanations.

As the foregoing Tables[1] contain so many particulars of the breadths of the *lodes* in every mine, it would be a needless repetition to enter more into detail respecting them.

III.—*The dip of lodes*

Is always so irregular, that no straight line can be drawn through the *lode* itself to connect distant points at different levels. The inclination often changes when the *lode* passes from one kind of rock to another; and when it does so from a soft into a very hard and compact one, it frequently becomes flatter, and occasionly, at a junction of different rocks, it may run for a few fathoms between them. It has been already stated[2] that the richest parts of almost every *lode* have the highest inclination. But the curvatures and irregularities in the underlie of *lodes* seem to depend on other causes beside the texture and composition of the rocks, and their own richness. These, whatever they may be, are not very apparent. One probably is the position which the *lodes* occupy with respect to the large granitic masses in their neighbourhoods. In *Table* CII. it may be seen that of 296 examples, 162 dip towards, and 111 from the nearest granite, and there are 23 doubtful cases. This shows a considerable prepon-

[1] Tables i. to xcviii. [2] *Ante*, p. 231.

derance in the number of inclinations towards the granite, but perhaps not one sufficiently great to be of material consequence. It may be in conformity to some law of this kind that the greater number of *lodes* in some districts, those of Helston, Camborne, Redruth, and Saint Austell for instance, incline towards the north;[1] whilst in others, as at Saint Just,[2] Gwinear, &c., the prevailing underlie is towards the south.[3] Of the 296 cases, in *Table* CII. before mentioned, 145 incline towards points of the compass north of the east and west, and 122 to points on the opposite side of that line, whilst 4 dip towards the east, and 11 to the west, and there are 14 nearly vertical. Thus, when the dip with regard to the granite is compared with that towards either of the cardinal points, there is a numerical preponderance in the former which is scarcely discernible in the latter.

Notwithstanding the very considerable difference which takes place in the degree of the inclination of a *lode* in different parts of its course, still the direction of its dip (so to speak) is generally the same: that is, a *lode* which underlies towards the north

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1 "In a line drawn from either Huel Fortune, or the United Mines, to Huel "Alfred, the lodes generally underlie northwards; which," (with some exceptions) "indeed, is the direction of the underlie of a very large majority "of all the copper lodes." Mr. Carne, *Cornwall Geo. Trans.*, ii. p. 97.

2 "Almost all the lodes which are situated in the northern part of St. Just "(north of the valley of Nancherrow) underlie towards the south, whilst most "of those in the southern part underlie northwards." Ibid, ii. p. 322.

3 "The lodes on another line, south of the last, extending from Trenoweth, "through Huel Abraham, Godolphin, &c., to West Huel Fortune, generally "underlie southwards. * * * There are a few exceptions on this line, but "they are not so numerous as on the other." Ibid, ii. p. 97.

will very seldom take a southerly inclination in any part of its bearing. Still there are many cases in which this happens; as at *Great Wheal Fortune*, *Wheal Trumpet*, *Stray Park*, *North Roskear*, and *Taylor's lode* in *The Consolidated Mines*, but the number is incomparably smaller than where the dip, though varying in degree, is always in the same direction.

Throughout Cornwall, and the west of Devon, the mean dip of the *lodes* may be about 70° from the horizon;[1] but in this respect there is a considerable difference between the *lodes* in the eastern and western districts. Thus, in the neighbourhood of Callington the mean dip is probably between 50° and 60°; at *Polgooth*, *Charlestown*, *East Crennis*, and indeed generally through the Saint Austell district, the average is little, if at all, more than 60°; at *West Pink*, *Wheal Kitty*, *Polberrow*, *United Hills*, and the rest of the Saint Agnes district, the mean is scarcely beyond that of Saint Austell. Indeed, at *The Virtuous Lady*, and *Wheal Friendship*[2] near Tavistock, the *Trevaunance lode*[3] in *Polberrow*, and in *United Hills*, the dip is so trifling that the

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1 "Tin and copper lodes are a few of them vertical or nearly so, while some "few have an inclination of about 60° from the perpendicular line; but the "general inclination is from 15° to 25°." Mr. Thomas, *Report*, p. 19.

See also, Mr. Burr, Mining Review, No. viii. (May, 1836), p. 212: Mr. R. W. Fox, Report of Royal Cornwall Polytech. Soc. (1836), p. 84: Professor Phillips, Lardner's Cabinet Cyclo., *Geology*, ii. (No. cxi.), p. 129.

2 The ore and rubbish are drawn out of this mine by means of waggons working on a railway, which is inclined at about 50°, and reaches nearly 200 fathoms deep.

3 This *lode* is so flat, that it affords a convenient road for the wheel-barrows of the miners.

labourers have access to some parts of the mines by means of steps cut in the lower *(foot) walls* of the *lodes*. There is also a very flat *lode* at *Ting Tang* and *Wheal Squire*.[1] It must not, however, be understood that these *flat lodes* are poor, or that the fact of their being sometimes rich, in any way contradicts what has been already[2] advanced, that the richer portions of the *lodes* are nearest to the perpendicular: for, although this is invariably the case, it does not follow that the *lodes* which are the most vertical are throughout the richest.

There are numerous examples of very productive *lodes* dipping in the same direction as the inclination of the surface;[3] as at *The Consolidated Mines, Wheal Reeth*, &c.: but they have quite as often, if not oftener, an opposite underlie; as at *Wheal Vor, Dolcoath, Fowey Consols*, &c.

At *Wheal Reeth, Wheal Vor, Cook's-kitchen, The United Mines, North Downs, Polberrow, Wheal Leisure, Fowey Consols*, and indeed in many other places, *lodes* dipping towards opposite points occur within very small tracts. When some of these fall in contact with others, they unite, and are not seen to separate again from each other: in other cases, one *lode* merely intersects another, whilst in some instances their vertical interferences are accompanied by those breaches in their continuity[4] which are

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[1] Mr. Thomas, Report, pp. 45–63. [2] *Ante*, p. 231.

[3] Mr. Burr, Mining Review, No. x. (1837), p. 192.

[4] Mr. Pryce, Mineral. Cornub., 107: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 136: Mr. Thomas, Report, pp. 20–23: Mr. Carne, Cornwall Geo. Trans., ii. pp. 91–98–120: M. Fournet, Etudes sur les Dépots Métallifères, p. 116:

locally called *throws, slides,* or *leaps.* These will be considered in a subsequent part of this Memoir.

The passage of *lodes* from one rock into another is seldom, if ever, attended by any change in their directions: whether, indeed, they traverse granite, slate, or *elvan,* seems in no case to influence their bearing, which rather appears to depend on some circumstances peculiar to the district, than on the nature of the containing rock. Where, however, two different rocks unite, the *lodes* not uncommonly run for a few fathoms between them; as at *Providence Mines, Wheal Vor, Wheal Buller,* and *Tresavean,* where for a short space they lie between granite and slate, and at *West Poldice, Great Wheal Fortune, Gwallon,* and *Dolcoath,* where they are in like manner bounded on opposite sides by slate and *elvan.*

The *lodes* in the Saint Just district differ from the general bearing more than any others; and in them vitreous copper is more plentiful than any other ore, whilst in the other districts copper pyrites is most abundant. It is, however, impossible to determine whether this difference may depend on the nature of the containing rocks, or on the directions of the *lodes.* In all the other tracts the courses of the *lodes* do not seem to exercise the slightest influence on their composition.

My own Paper, Proceedings of the Geol. Soc., i. (1832), p. 405; and another, Edin. New Phil. Journal, xxii. (1836), p. 160: Mr. R. W. Fox, Report of the Royal Cornwall Polytech. Soc. (1836), p. 87: Mr De la Beche, Report, p. 334.

IV.—*The directions of the lodes*

In the different districts are particularized in Table ciii.; but the mean of each district is as follows:—

Saint Just — — — —	35° N. of W.
Saint Ives — — — —	8° N. of W.
Marazion — — — —	1° S. of W.
Gwinear, &c. — — —	2° N. of W.
Helston — — — —	16° S. of W.
Camborne, &c. — — —	20° S. of W.
Redruth, &c. — — —	22° S. of W.
Saint Agnes — — —	22° S. of W.
Saint Austell — — —	13° S. of W.
Tavistock, &c. — — —	9° S. of W.
and the average of the whole	4° S. of W.

From this statement it will be remarked that the *lodes* of the Saint Just district bear much more to the northward of west than those of any other:[1] those of Saint Ives[2] also "carry their heads" somewhat in the same direction, but with less deviation from the line of east and west. The *lodes* in the Marazion and Gwinear districts[3] vary even less from an easterly and westerly direction; whilst in that of Helston[4] they *strike* considerably to the southward of west; this deviation increases in the Camborne[5]

[1] Mr. Carne, Corn. Geo. Trans., ii. pp. 89–321: My own Papers, Edin. New Phil. Journal, xxii. (1836), pp. 159–272; Annales des Mines, xi. (1837), p. 588; Annals of Electricity, i. p. 125: Mr. R. W. Fox, Report of the Royal Cornwall Polytech. Soc. (1836), pp. 83–93: Mr. De la Beche, Report, p. 308.

[2] Mr. De la Beche, Report, p. 306.

[3] Ibid, p. 307. [4] Ibid, p. 307. [5] Ibid, p. 306.

DIRECTIONS OF THE *LODES* IN THE DIFFERENT DISTRICTS.

Districts.	N. to 10° W. of N.	10-20° —	20-30° —	30-40° —	40-50° —	50-60° —	60-70° —	70-80° —	80° W. of N. to W.	W. to 10° S. of W.	10-20° —	20-30° —	30-40° —	40-50° —	50-60° —	60-70° —	70-80° —	80° S. of W. to S.
Saint Just.....	1	5	5	10	10	8	5	4	1	..	1	2	..	1	1	1	..	1
Saint Ives.....	..	..	..	..	1	..	..	..	1	1	3	7	6	..	1	..	..	..
Marazion	..	..	..	..	..	..	2	..	1	6	2	3	1	..	..	..	..	..
Gwinear, &c. ..	..	..	..	..	4	2	3	2	1	2	8	5	2	..	..	..	..	..
Helston	..	..	..	..	..	1	3	..	..	..	1	8	2	1	1	..	..	..
Camborne, &c. .	..	..	2	..	..	..	1	1	1	4	6	12	11	6	..	..	..	..
Redruth, &c. ..	..	..	..	..	..	..	..	1	1	2	15	24	3	2	1	..	..	..
Saint Agnes ...	..	..	..	..	..	1	1	..	1	1	3	16	5	1	..	1	..	..
Saint Austell ..	..	..	..	..	1	1	2	..	6	7	1	1	..	..	..	3	3	..
Tavistock, &c. .	..	..	..	..	1	..	..	1	1	2	2	2	..	..	..	1	..	..
Total....	1	5	7	10	17	13	17	9	14	25	42	80	30	11	4	6	3	1

Table CIII.

tract, and reaches its maximum in the central portions of the great mining field of Cornwall, viz., in the Redruth and Saint Agnes[1] districts. The mean direction of the *lodes* near Saint Austell[2] again more nearly approaches the east and west line; and in the vicinity of Tavistock[3] the approximation is still closer.

Fig. 5, Pl. XI. may give an idea what would be the course of a *lode* could it be traced continuously through these districts, and if it took successively the mean bearing of the *lodes* in each. This, of course, is only hypothetical, as there is no instance known in which a *lode* has been traced with certainty from one district into another.[4] On the whole, the directions of the *lodes* have a kind of coincidence with that of the granitic range which appears at intervals in the tract from Dartmoor to the Land's-end; and there may perhaps be slight similarity to the course of a line drawn through the centre of Cornwall from east to west:[5] but the resemblance is by no means a close one.

In the Saint Just district indeed, many of the *lodes* seem as if they radiated towards the sea from some central point inland: thus, at *Levant*, *Wheal Cock*, and other mines in the north of that parish, several of the *lodes* bear but a few degrees west of north, whilst in the southern parts of it they are generally much nearer to east and west.

Although the mean bearings of the *lodes* differ in different districts, yet, when each tract is taken

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[1] Mr. De la Beche, Report, p. 305. [2] Ibid, p. 303. [3] Ibid, p. 302.
[4] *Ante*, p. 175. [5] Mr. De la Beche, Report, p. 309.

singly, there is a general approach to parallelism in the principal *lodes* in it: and the small differences which occur in their directions are commonly in spots at some distance from each other. This is the case in the Saint Ives and Marazion districts, and especially in those of Helston and Redruth; in all which the courses of the greater number of the *lodes* have a considerable uniformity.

To a certain extent this also obtains in most of the other districts: for in them the principal or *Champion*[1] *lodes* have a similar coincidence, or the differences in their directions take place in rather distant localities. But in the Gwinear and Camborne districts there are other *lodes* (locally called *Caunter lodes*[2]) which differ from 21° to 75° (the mean difference being 54°) from the directions of

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[1] *Ante*, p. 176.

[2] "All veins crossing each other may be termed Contras in respect of each "other, as their courses are in opposition; but from the best information I can "procure, all those Gossans which are direct east and west, run through every "other Lode like Cross-Gossans, but do not disorder them in the same man-"ner: therefore I chuse to fix the name of Contra, vulgarly called Caunter, to "these direct east and west Lodes." MR. PRYCE, *Mineral. Cornub.* p. 105.

"There occurs still another species of vein, of which the course or direction "is generally about north-east and south-west, and which therefore is oblique "in respect to all other veins: from this circumstance I presume it to have "obtained the name of *Contre* or *Caunter*."

MR. WM. PHILLIPS, *Geo. Trans.*, o.s. ii. p. 139.

"There are some few lodes which vary thirty or forty degrees from the "general direction, and are commonly called *counter* lodes."

MR. THOMAS, *Report*, p. 19.

"By *contra lodes* (I mean) metalliferous veins whose direction is from 30° "to 60° from east and west." MR. CARNE, *Cornwall Geo. Trans.*, ii. p. 85.

"There is, however, a metalliferous series of veins the *contra* or *counter lodes*, "which have a direction about N.W. and S. E."

My own Paper, *Edin. New Phil. Journal*, xxii. (1836), p. 159.

See also, Mr. Burr, Mining Rev., No. viii. (1836), p. 210: Mr. R. W. Fox, Report of Royal Corn. Polytech. Soc., (1836), p. 83: Prof. Phillips, Lardner's Cabinet Cyclo., *Geology*, ii. (No. cxi.): Mr. De la Beche, Report, p. 365.

the *Champion lodes* in the same mines; though they may perhaps present no greater differences when compared with the bearings of other *Champion lodes* at distant spots, than these *Champion lodes* exhibit when compared with those in other places. The *Caunter lodes* have also similar discordances when compared with each other. These differences are perhaps best seen when comparing with each other the directions of the *Fancy Caunter* and *Colenso's lodes* in *Herland*, the *Gooseberry* and *Hicks's lodes* in *Binner Downs*, all the *lodes* in *Godolphin*, except that which is there called the *Caunter*,[1] *Longclose Caunter* and *Reeve's lodes* in *East Wheal Crofty*, the *Caunter lodes* in *Wheal Providence*, *Carnsise*, *Dolcoath*, *North Roskear*, and *East Pool*, with each other, and with the other *lodes* in the same mines, and the *lode* of *Wheal Strawberry* with the *South lode* in *Binner Downs* which is the *Champion lode* nearest to it.

The *Caunter lodes* have no distinctive character but that of direction: they invariably bear to the north of the *Champion lodes* as they go westward, the mean *strike* being 31° N. of W.; and the greatest difference in the direction of *Caunter lodes* is between those of adjoining mines, *East Wheal Crofty* and *East Pool*, which is 49°.

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1 In *Godolphin* the only *lode* which bears 25° S. of W. is called the *Caunter*.

"Cornish miners always give the name of a contra-lode, or caunter, to those "veins which do not hold the directions of their main lodes, and that, therefore, "which may be termed a contra-lode in one district coincides in direction with "the true lodes of another." MR. DE LA BECHE, *Report*, p. 365.

The intersections of the *lodes* follow no general rule.[1] They sometimes unite and form one single *lode*, as at *Great Wheal Fortune, Binner Downs, Dolcoath, Ting Tang*, &c.; in which mines it is somewhat remarkable that they fall together and unite as they go westward, and bifurcate and divide as they are pursued in the opposite direction. In some cases, as at *East Wheal Crofty*, both *lodes* at the point of intersection split into poor and small quartzose strings; whilst in others, one simply crosses the other, and occasionally one or the other is *heaved*.

THE CROSS-COURSES, FLUCANS, TRAWNS, OR GUIDES.

Those veins which, with rare exceptions, yield neither tin nor copper ores, are called *Guides* in the Saint Just district,[2] *Trawns* in that of Saint Ives,[3] and in the other parts of Cornwall *Cross-courses*,[4] when chiefly composed of quartz, and *Flucans*[5] when consisting of clay. But for the sake of greater simplicity I shall throughout this Chapter apply to all of them the term *Cross-veins*, which is one free

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[1] My own Paper, Proceedings of the Geological Society, i. (1832), p. 405.

[2] Mr. Carne, Corn. Geo. Trans., ii. p. 109. [3] *Ante*, p. 19, note.

[4] Mr. Pryce, Mineral. Cornub., p. 94: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 134: Mr. Thomas, Report, p. 21: Mr. Carne, Cornwall Geo. Trans., ii. p. 107: M. Fournet, Etudes, sur les Dépots Métallifères, p. 114: Mr. Burr, Mining Review, No. viii. (May, 1836), p. 230: My own Paper, Edin. New Phil. Journal, xxii. (1836), p. 159: Mr. R. W. Fox, Report of Royal Corn. Polytech. Soc., (1836), p. 83: Mr. De la Beche, Report, p. 296.

[5] Mr. Pryce, Mineral. Cornub., p. 94: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 134: Mr. Carne, Corn. Geo. Trans., ii. p. 114.

from objection, and not inconsistent with either of the others.

As this class of veins is rarely metalliferous in the vicinity of *lodes*, and therefore in such places holds out but little encouragement to the miner, the workings on *cross-veins* are seldom extensive. Indeed, were not the *lodes* generally cut through, and frequently *(heaved)* not found in corresponding positions on opposite sides of them, they would probably have been scarcely at all examined.

The directions of these *cross-veins*, as their provincial designation indicates, are transverse to those of the *lodes* in most cases, though the bearings of different ones in the same districts vary considerably.

It must not, however, be lost sight of that there are veins which, having a similar direction to the *cross-veins*, are often productive of lead ores. In the cases of *Redmoor* and *Wheal Betsy* this takes place in the immediate neighbourhood of copper *lodes;* but it is far more usual for such veins to become rich at considerable distances from the *lodes*, when the last are profitable, as at *Wheal Golden* and *Penhale.*

The same *cross-veins* are occasionally traced through several mines. It is the same which divides *Dolcoath* from *Cook's-kitchen*, and *North Roskear* from *East Wheal Crofty: Tiddy's* or *Paul's cross-course* is also traced through *The United* and *Consolidated Mines*, and thence to *Poldice:* the same *flucans* may also be identified in *East Wheal Damsel* and *Wheal Jewel.* In very few cases, however, can

they be thus recognized at distant spots: and in not a single instance have I been able to trace the same *cross-vein* into adjoining districts. It has indeed been said[1] that the *great cross-course* which *heaves* the *lodes* in *Wheal Peever* 72 fathoms can be traced southward to the British, and northward to the Bristol Channel; but the proof is far from satisfactory: for, though there are several *flucans* in *Wheal Damsel*,[2] *Wheal Squire*,[3] and *Poldory*[4] which *heave* the *lodes* towards the same (right) hand as the *great cross-course*, neither of them has been traced to a junction with it. Again, in the opposite direction, there are few, if any, mining operations of sufficient magnitude to determine the question; and the only considerable *heave* seen in any spot northward of *Wheal Peever*, and on the same meridian, is in *Cliff Down*, the western part of *Wheal Towan*, and this is toward the opposite (left) hand.[5] In *Wheal Peever*, on the contrary, though some of the *lodes* dip towards the north and others to the south, the *heaves* of all of them are invariably towards the right. Of the identity of the *cross-veins* which thus produce these dissimilar *heaves* in distant spots, no proof can be afforded, because their courses have neither been traced at the surface nor underground continuously through the intervening tract.

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[1] Dr. Berger, Geo. Trans., o.s. i. p. 165: Mr. Williams, Ibid, iv. p. 142: Mr. Carne, Corn. Geo. Trans., ii. p. 108: Mr. Burr, Mining Journal, No. viii. (1836), p. 232.

[2] Mr. Thomas, Report, pp. 22-52. [3] Ibid, p. 64. [4] Ibid, p. 49; *Ante*, p. 88.

[5] In Sheet xxxi. of the Ordnance Geological Survey, a continuous line (indicating a *cross-vein*) is drawn from *Wheal Peever* to *Cliff Down*; and the *heave* in the latter is incorrectly represented as being towards the right hand, whereas it really is to the left.

The *cross-veins* split into branches, both horizontally and vertically, much in the same manner as the *lodes* do; as, for instance, at *Wheal Vor* and *Wheal Friendship*. They also frequently dwindle and disappear both in length and depth;[1] as at *Relistian*, *Godolphin*, and *Wheal Buller:* and in some cases, as in *Poldory*, they appear at certain *levels*, but have not been discovered either above or beneath.[2]

Different *cross-veins* take very different directions, even within short distances of each other, and must therefore often fall in contact; but as they are seldom pursued far, few of their intersections have been observed.[3] At *Polladras Downs* a *flucan* intersects a *cross-course*, but there is no *heave*.

The *cross-veins*, like the *lodes*, are in different spots composed of very dissimilar substances: their principal ingredients are, however, quartz and clay, and the same vein is called either a *cross-course*, or a *flucan*, as one or the other of these predominates;[4] and in this respect there is often an entire change within very short distances. They may be defined as merely quartzose varieties of the contiguous rocks; but they differ from the *lodes*, not only in being seldom metalliferous, but also in the peculiar and generally crystalline character of the quartz.[5]

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[1] Mr. Thomas, Report, pp. 35-36. [2] Ibid, p. 35; *ante*, p. 89.

[3] Mr. Thomas, Report, p. 21: Mr. Carne, Corn. Geo. Trans., ii. p. 110.

[4] Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 134: Mr. Thomas, Report, p. 24: Mr. Carne, Cornwall Geo. Trans., ii. p. 107: My own Paper, Edin. New Phil. Journal, xxii. (1836), p. 150.

[5] A character acknowledged by practical miners from time immemorial. See Mr. R. W. Fox, Phil. Mag. and Annals, vi. (1829), p. 19; also, Report of the Royal Corn. Polytech. Soc. (1836), p. 89.

The other ingredients of which they consist are often very soft, or even converted into clay from the percolation of water: yet in many places where the rock is slaty its schistose structure still remains, and the arrangements of its laminæ coincides with that of the slate in contact with it, in which respect it agrees with what has been remarked in the *lodes*.

As the *cross-veins* generally intersect the *lodes*, their quartzose portions afford almost the only uninterrupted natural channels for the circulation of water underground;[1] and hence the rock is softer in their vicinity. But this circulation can only take place in those portions of them which contain no clay, for those *flucans* which contain it most effectually act as dams; on which account mining leases *(Setts)* are often bounded by *cross-veins*.[2] As the directions of the *cross-veins* are transverse to those of the *lodes*, and because of the rocks in their neighbourhood are softer, transverse drifts *(cross-cuts)* are frequently extended on them, for the recovery of *lodes* which have been *heaved*, as well as for the discovery of other parallel *lodes*.

In their characters, as composition, size, dip, and direction, there are irregularities somewhat similar to those which have been noticed in the *lodes*, and they may be conveniently examined in the same

[1] Dr. Borlase, Natural History, p. 147: My own Papers, Phil. Mag. and Annals, ix. (1831), p. 170; London and Edin. Phil. Mag., i. (1832), p. 287; Ibid, iii. (1833), p. 417: Mr. R. W. Fox, Report of Royal Cornwall Polytech. Soc. (1836), p. 106: Mr. De la Beche, Report, p. 394.

[2] Mr. Pryce, Mineral. Cornub., pp. 94–100: Mr. Thomas, Report, p. 25: Mr. R. W. Fox, Phil. Mag. and Annals, vi. (1829), p. 19: Dr. Buckland, Bridgewater Treatise, i. p. 546.

order. Whilst the results attending their intersecting the *lodes* are reserved for separate consideration.

I.—*Composition of the cross-veins, and their relations to the containing rocks.*

1. ***The relations between the cross-veins and the containing rocks*** may, as in the corresponding case of the *lodes*, be considered in respect of their structure and composition.

(*a.*) ***Structure of the cross-veins, and its relation to that of the rocks.***—It has been remarked[1] that the *lodes* are to some extent traversed longitudinally by joints similar in all respects to those of the rocks. These joints, when taken in short lengths, seem to divide the whole substance of the *lode* into a great number of small parallel veins; but, when a large surface is exposed, the irregularity, both in the dip and the direction of the joints, occasions their frequent intersection, of which *Pl. XI., Fig.* 6, will give an imaginary, but sufficient, illustration. It has also been stated, in the preceding Chapter, that the joints of the *lodes*, which resemble in every particular those of the contiguous rocks, are most numerous in the more quartzose portions.[2] On referring to *Table* XCIX. it will be seen, that of 213 joints there arranged, 117 bear between north and north-west; and, if we anticipate a little, we shall find, in *Table* CVI., that of 163 *cross-veins* there tabulated, the directions of 118 are comprized within the same limits.

[1] *Ante*, p. 180. [2] Ibid, p. 179.

Where therefore we have so striking a concurrence of circumstances as a great, and in places even the exclusive, prevalence of quartz[1] in the composition, and such a coincidence between the directions of the greater number of the joints and those of the *cross-veins*, we appear to have conditions the most favourable to the abundant developement of joints in the *cross-veins*. Accordingly one of the most remarkable features in their structure is the prevalence of joints;[2] varying, however, in direction and dip, but preserving certain limits; so that, whilst they intersect each other, their curvatures seem projected on the same lines, which are in fact the directions of the *cross-veins*. To this great abundance of their joints is clearly owing that the *cross-veins* have generally more distinctly marked *walls* or boundaries than the *lodes*; for where joints are so plentiful it is not very remarkable that some of them should be found to coincide with the lines which, on either side, occur where a difference of mineral structure commences. This veined structure is so prevalent in the vicinity of the *cross-veins* that the rock on both sides often, for several fathoms, consists as it were of alternate veins of quartz and of the contiguous stratum, which equally cut off each other in their horizontal and vertical progress;

[1] Mr. Wm. Phillips, Geo. Trans., o.s. ii. pp. 134–148–150: Mr. Thomas, Report, p. 24: Mr. Carne, Corn. Geo. Trans., ii. p. 107: Dr. Boase, Primary Geology, p. 184, *note*: M. Fournet, Etudes, sur les Dépots Métallifères, p. 114: Mr. Burr, Mining Review, No. viii. p. 230: Mr. R. W. Fox, Report of Royal Corn. Polytech. Soc. (1836), pp. 83–88.

[2] Mr. Carne, Corn. Geo. Trans., ii. p. 107: Mr. R. W. Fox, Report of Royal Corn. Polytech. Soc. (1836), p. 89: Mr. De la Beche, Report, p. 321.

as, for example, in the *great cross-course* at *Wheal Peever*, the eastern *cross-course* at *Wheal Friendship*, &c. These veined portions of the adjacent rocks are, commonly enough, much decomposed or softened by the water which percolates through the *cross-veins;* although, when of schistose structure, their laminar arrangement is still preserved.

Equally conspicuous with the jointed structure is another, even more characteristic of *cross-veins*, but which is confined to their quartzose portions alone, and to a kind of irregular crystalline arrangement of the quartz the axes of the crystals being disposed across the vein.[1] This crystallization seldom or never presents a symmetrical form, but the whole consists of a congeries of small crystallized masses bounded by faces, which are disposed at right angles to the direction of the vein: they intersect in almost every imaginable manner, the vein being at the same time longitudinally traversed and marked by the prevailing jointed structure already mentioned.

The *cross-veins* have also two other series of joints; one crossing them nearly at right angles, the other diagonally. This is so strongly marked that when the veins bear N. and S. the oblique joints run S.E. and N.W.; and, on the contrary, when the *cross-veins* have the latter direction the former is often that of the diagonal joints. The best displayed *cross-vein* in Cornwall is that which has been

[1] Mr. R. W. Fox, Phil. Trans. (1830), p. 406; Report of Royal Polytech. Soc. (1830), p. 89: Mr. De la Beche, Report, p. 340: Professor Phillips, Cabinet Cyclo. (No. cxi.), *Geology*, ii. p. 132. I have seen some fine examples of this structure at Saint John, New Brunswick.

extensively quarried near Hayle Foundry, where every variety of jointed and other internal structure is exposed to the day: on the eastern side of Perran Porth a vertical section of a very similar one may also be conveniently examined.

In a few cases, as at *Pembroke*, and *Wheal Calmady*,[1] in the clayey parts of the *cross-veins* are small globular masses[2] which consist of a nucleus of quartz surrounded by quartzose slate, and are probably mere concretions in the slaty mass, harder in texture from their siliceous composition, and developed by the disintegration of the rock of which they had originally formed a part. This structure has been already mentioned as prevailing in the granite[3] and *elvan*,[4] and also in some *lodes*.[5]

In the granite tracts many of the *cross-veins* consist almost entirely of granitic matter: this is commonly in a state of disintegration, and often contains much more felspar, and occasionally more mica also, than the contiguous rocks. A larger portion of the felspar is usually distinctly crystallized, and, in many cases too, there seems something like an approach to uniformity in the positions of the crystals; as at *Wheal Union*, *Saint Ives Consols*, *Wheal Trewavas*, *Cairn Brea Mines*, &c.: a circumstance which has already been noticed in the granitic series.[6]

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[1] Near Bridestow, Devon.

[2] Similar spheroidal concretions are plentiful in the *cross-veins* of the *Knockmahon Mines*, near Waterford.

[3] *Ante*, p. 147. [4] Ibid, p. 163. [5] Ibid, p. 183. [6] Ibid, p. 145.

(*b.*) ***Relations between the mineral composition of the cross-veins and the containing rocks.*** **1. *Junctions between the cross-veins and the rocks.*—The crystallized portions of all veins, whether *lodes* or *cross-veins*, are generally homogeneous in composition, and seldom contain foreign substances in abundance: and the crystalline character, which prevails to so great an extent as we have just seen in the quartz contained in *cross-veins*, seems therefore peculiarly inimical to the mixture of the earthy constituents of the adjacent rocks with it. Thus, the crystalline portions of the *cross-veins* have usually a distinct and separate arrangement, and present but few traces of union with and resemblance to the contiguous strata.**

But in a large number of *cross-veins* this crystalline character is very subordinate, and in these the quartz is mixed and incorporated with the substance of the containing rock in the same manner as in the *lodes*.[1] Between these veins and the rocks they traverse there is a transition in every respect similar to that which has been already described[2] as taking place in the case of the *lodes* under like circumstances; as in the *eastern cross-course* at *Wheal Vor*, and *Tiddy's cross-course* in *The United* and *Consolidated Mines*.

In some cases this resemblance becomes perfect and absolute identity: for example, at *Wheal Messer cross-course* in *North Downs* the clay passes into the slate-rock by shades, so imperceptible that the

[1] *Ante*, p. 185. [2] Ibid, p. 184.

laminæ are not obliterated in the clay, and in position they perfectly coincide with those in the slate: similar facts occur in the *flucans* at *Duffield*, in the *Privateer flucan* at *Herland*, and in many other places.

At *Wheal Trumpet*, and in numerous other localities, there is also the closest resemblance between the granite of the *cross-veins*, and of the contiguous *Country*.

But, whether the containing rock be granite, slate, or *elvan*, there are in all the quartzose parts of the *cross-veins* many small strings of quartz which include between them *horses* of the *Country*:[1] and these enclosed portions of rock are in like manner traversed in all directions by minute veins striking from one to the other of the larger ones, and making the whole of the included mass a network of quartzy veins. When the *horse* thus surrounded and traversed by veins consists of slate, the laminæ in it have a perfect coincidence with those which divide the contiguous rock; as in *Tiddy's cross-course* in *The United Mines*, the *great cross-course* in *Wheal Friendship*, &c.

(*b.*) 2. *The composition of cross-veins in different rocks.*—From the introductory remarks of the present Chapter it will be understood that some parts of the *cross-veins* consist of common, and others of crystalline, quartz;—that the quartz is sometimes mixed with the matter of the adjacent rocks, and that occasionally the latter entirely replaces the former.

[1] *Ante*, p. 176.

It now remains to be shewn that the passage of the vein from one kind of rock to another is attended by a corresponding change in its mineral composition.

The *cross-veins* seem to be rather less numerous in granite than they are in slate; and, though often quartzose, and the quartz frequently crystalline (as at *Wheal Mary, Wheal Ann, Cook's-kitchen,* &c.), they more commonly consist of granite, which sometimes closely resembles the contiguous *Country*, but is generally more felspathic, and occasionally contains more mica also. The quartzose portions are likewise more minutely divided by planes of crystallization, and there is often a thin coating of ochery iron ore in the small crevices.

In *elvan* their composition is mostly that of the rock, yet containing also irregular masses of quartz throughout; but the examples in which crystalline quartz occurs in the *cross-veins* whilst traversing the *elvan-courses* are very rare: some cases, however, of this kind occur at *Wheal Prudence* and *Trevellas Downs*.[1]

In slate a crystalline structure of the quartz in the *cross-veins* is more usual; but perhaps an equal number consists of quartzose slate and of slaty clay.

The most instructive instances, however, which prove undoubtedly that the same intimate relations which subsist between the *lodes* and the rocks they traverse occur also between the *cross-veins* and the containing strata, are found when the same vein can be traced in its passage from one rock into another.

[1] *Ante*, p. 107.

The *eastern cross-course* at *Tincroft* is a remarkable one of this kind; as in slate it consists of slate and quartz, in *elvan* of *elvan* and quartz, and in granite of disintegrated granite enclosing quartz in irregular masses. *Wheal Beauchamp* eastern and western *flucans* present similar phenomena; and like facts occur in *Wheal Trannack, Dolcoath, Ting Tang, Wheal Virgin (Consolidated Mines), Cardrew Downs, Wheal Devonshire, Wheal Prudence, Polgooth,* and in many other mines.

Again, the same *cross-vein,* in traversing rocks of the same class, frequently varies in the mode in which its constituents are aggregated: and though these alter in their relative proportions, no new ingredients appear. From quartzose it becomes clayey;[1] or, in mining language, from a *cross-course* it changes to a *flucan.* An alteration of this kind takes place within a very few fathoms in the *eastern cross-course* at *Duffield,* in the *flucan* at *Polladras Downs,* in the *little flucan* at *Cardrew Downs,* in the *cross-course* at *Wheal Prudence,* in the *cross-course* at *Fowey Consols,* and in the lead *lode* at *Redmoor;* the instances in which this happens are, in fact, almost innumerable, and in all of them there is probably some change in the composition of the contiguous rock.

The same *cross-vein* in the same locality often consists partly of quartz and partly of clay, sometimes intimately mixed, at others affecting separate veins; which, however, never preserve the same

[1] My own Paper, Edin. New Philosophical Journal (1836), xxii. p. 158: Mr. R. W. Fox, Report of Royal Cornwall Polytech. Soc. (1836), p. 88.

relative situations for any great extent either in length or depth.[1]

Frequently, though not universally, where the *cross-vein* consists wholly of soft and friable materials it is traversed by numerous curved and irregular joints, which are sometimes filled with unctuous clay. These intersect each other in all directions, and thus divide the substance of the vein into very oddly-shaped masses, which are often marked on all sides with irregular striæ, and are frequently highly polished. Many examples of a similar structure on a small scale have been already described as occurring in the *lodes*.[2]

(*b.*) 3. *The distribution of metallic substances through the cross-veins.*—The metallic ores sometimes found in the *cross-veins* are dispersed through the quartzose and other earthy minerals much in the same manner as they are in the *lodes*. Of these the ores of iron and lead are the chief; and indeed the *cross-veins* yield by far the largest portions of them which are produced in Cornwall.

Perhaps more iron ore is afforded by the *cross-vein* at Restormel[3] than by any other in the County: hematite, specular, and hydrous oxide of iron are the most common ores in it, but the oxide of manganese, opal, jaspar, and chalcedony have also been plentiful, and other minerals have been occasionally found. In Saint Just most of the *cross-*

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[1] Mr. Carne, Cornwall Geo. Trans., ii. p. 107.

[2] *Ante*, p. 182. [3] Ibid, p. 128.

veins (guides[1]*)* are very ferruginous, but not sufficiently so to offer any inducement to the miner. At Ladock, Roche, and other parts of the County, iron ores have recently been obtained in considerable abundance.

The *cross-veins* which have been richest in lead ores are those of *Wheal Golden*,[2] *Penhale, Redmoor*, and *Wheal Betsy;* but small quantities have also been extracted from some others: for example, at *West Pink*. There is little to particularize in these, except that no *lodes* have been worked in the immediate vicinity of *Wheal Golden, Penhale*, and *Wheal Betsy;* whilst at *Redmoor* and *West Pink* the *cross-veins* have yielded lead ores almost in contact with *lodes* affording both tin and copper ores in abundance. In *Wheal Budnick*, also, one of the *cross-veins*, which is supposed to be a southerly prolongation of that in *Wheal Golden* and *Penhale*, yields a little lead ore at its point of contact with the tin *lode*.

At *East Wheal Rose* a *lode* and *cross-vein* meet nearly at right-angles, and are almost equally productive of lead ore for many fathoms on either side of the point of contact: a case, as far as I know, without a parallel in Cornwall.[3]

All the galena in *cross-veins* is combined in variable proportions with silver, which is probably in the vitreous state.

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[1] *Ante*, p. 9, *note*. [2] Mr. Carne, Cornwall Geo. Trans., ii. p. 112.

[3] With the particulars of this curious and unique example I have been favoured by Robert Michell, Esq., of Truro.

At *Herland* one of the *cross-veins*[1] yielded abundance of silver:[2] sometimes in the native state, at

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1 "Common galena generally contains a very small proportion of silver. "But the proportion varies greatly in those which may be strictly termed "argentiferous, and which are worth smelting for the silver they contain. "11½ ounces of silver to the ton of ore is the general average of the lead of "the North of England. That of Huel Pool in Cornwall yielded 60 ounces; "and that of Guarneck (Garres?) mine near Truro 70 ounces. One ton of the "ore of the South Hoo mine, adjoining Beeralstone in Devonshire, lately "yielded 135 ounces of pure silver."

MR. WM. PHILLIPS, *Mineralogy* (3rd Edition), p. 335.

"The proportion (of silver) is sometimes exceedingly minute, being not more "than 1 ounce or 1½ ounce per ton in the metal raised in Derbyshire and Shrop-"shire, while in every ton of the lead from Devon and Cornwall there is found "from 20 to 30 ounces of silver. The produce of other mines contains the "more precious metal in various proportions between these two extremes."

Penny Cyclo., xiii. p. 371.—Art. "Lead."

"The lead of commerce is rarely free from traces of silver."

DR. TURNER, *Elements of Chemistry*, p. 593.

The quantities of pig lead obtained from the mines of this Kingdom have never been very correctly ascertained.—They were stated to have been in the year 1828,—

From	Cumberland, Durham, and Northumberland —	22000	tons
„	Yorkshire — — — — — —	4700	„
„	Derbyshire — — — — — —	3000	„
„	Shropshire — — — — — —	1800	„
„	Devon and Cornwall — — — —	2000	„
„	Wales — — — — — —	12000	„
„	Scotland — — — — — —	1000	„
„	Ireland, Isle of Man, &c. — — — —	500	„
	Total —	47000	tons.

MR. JOHN TAYLOR, *Records of Mining*, p. 173; *Ency. Metrop.* (Mixed Sciences) vi. p. 195.

In 1835 the quantity of pig lead is reported to have been,—

From	Cumberland, Durham, and Northumberland —	19626	tons
„	Yorkshire — — — — — —	4700	„
„	Derbyshire — — — — — —	4000	„
„	Shropshire — — — — — —	3539	„
„	Devon and Cornwall — — — —	140	„
„	Wales — — — — — —	10757	„
„	Scotland — — — — — —	1300	„
„	Ireland, Isle of Man, &c. — — — —	2050	„
	Total —	46112	tons.

MR. JOHN TAYLOR, *Mining Review*, No. ix. (1837) p. 35.

2 The Rev. Malachy Hitchens, Phil. Trans. (1801) p. 159: Mr. Wm. Phillips, Geo. Trans. ii. o.s. p. 147: Mr. Carne, Cornwall Geo. Trans., ii. p. 113.

others in that of vitreous silver ore. It was dispersed through the vein in much the same manner as the ores generally are in the *lodes:* in the shallower parts *gossan* accompanied it, and at greater depths it was mixed with arsenical and iron pyrites (white and yellow *mundic*). The whole was distributed through a white crystalline quartz, the cavities (*vughs*) in which were often lined with capillary native silver.

Native copper and the capillary red oxide of copper occur in *Tiddy's cross-course*, both in the *United* and *Consolidated Mines;* and, in the latter, vitreous and black copper ores also. In neither can any *lode* be specified with which in these respects the *cross-course* or its metallic contents have any obvious connexion: though in both mines there are several *lodes* in the immediate vicinity of the parts of the *cross-course* which yield the ore. In *Ting Tang* a vein of vitreous copper ore, 2 feet in breadth, accompanies the *western flucan* for $3\frac{1}{2}$ fathoms, throughout the whole distance which the *middle lode* is *heaved*, and thus connects the portions of the *lode* which are on opposite sides of the *flucan*. At *Wheal Friendship* a continuous vein of copper pyrites $1\frac{1}{2}$ foot in width, in similar manner unites the parts of the *Caunter lode* on either side of the *great cross-course*, through the whole extent of the *heave*, which is 4 fathoms. Copper pyrites also occurs in *Chambers's flucan* at *Herland*.[1]

[1] "Cross courses are in general unproductive either of tin or copper; but "some rare instances have occurred in which both these metals have been

Blende abounds both in the *western cross-course* at *Trevaskus*, and in *Wheal Messer cross-course* at *North Downs;* in the former it is mixed with fluor.

Some tin ore occurs in the *cross-course* at *Beam*, and in several other places,[1] but in none of them in much abundance.

The ores of cobalt[2] and antimony[3] are also said to have been met with in a few *cross-veins;* and most of them, which are very quartzose, in some part of their course contain large quantities of iron pyrites; as, for example, in *Wheal Falmouth, Wheal Vor, Herland,* &c.

It is a recognized fact[4] that the same ores are seldom found in the same districts in veins at or near right-angles with each other; indeed, *East Wheal Rose*[5] is the only example of the kind with which I am acquainted; and, although lead ore has been found near the tin *lodes* at *West Pink*, yet it is almost as rare for two series of veins to be, within

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"found in them. In Polgooth, Screed's lode, which is a cross course, was rich "in tin. In Huel Music, two small gossan cross courses have produced some "of the richest copper ore in Cornwall. In Wheal Jubilee also the copper "lode is a cross course. It, however, frequently happens that cross courses, "on intersecting rich copper or tin lodes, partake of their riches for a short "space. In Huel Peever the cross course was rich in tin several feet north of "the point at which it intersected the tin lode; and in Treskirby, Kinsman's "cross course was rich in copper for about ten feet north of its intersection of "a copper lode, but on the southern part they were quite barren."

MR. CARNE, *Cornwall Geo. Trans.*, ii. p. 112.

1 Mr. Hawkins, Corn. Geo. Trans., i. p. 148: Mr. Carne, Ibid, ii. p. 112.

2 Mr. Pryce, Mineral. Cornub., p. 50: Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 135: Mr. Thomas, Report, p. 25: Mr. Carne, Cornwall Geo. Trans., ii. p. 113: Mr. R. W. Fox, Report Royal Corn. Polytech. Soc. (1836), p. 90.

3 Mr. Wm. Phillips, Geo. Trans., o.s. ii. p. 135: Mr. Carne, Cornwall Geo. Trans., ii. p. 113.

4 My own Paper, Edin. New Phil. Journal, xxii. (1836) p. 159.

5 *Ante*, p. 268.

small limits, productive even of different ores. Thus the *cross-course* in *Wheal Budnick*, though it yields minute quantities of lead ore near the tin *lode*, affords by far the greatest part of it in *Wheal Golden* and *Penhale*, which are more than a mile distant: at *Wheal Friendship*, also, the copper *lode* is intersected by the *cross-vein* which has been very productive of lead ore in *Wheal Betsy*, but its riches have not appeared until at a considerable distance from the point of intersection. It may be added, as not unworthy of notice, that the same *lode* may be intersected by several *cross-veins*, some of which yield abundance of lead ore at distant spots, whilst the rest have been entirely unproductive, so far as they have yet been examined; as at *Wheal Friendship*.

There are, however, exceptions to the rule just laid down. In the *silver cross-course*, at *Herland*, the greatest quantity of ore was found in the vicinity of the *lodes*, some of which, indeed, also contained a little silver ore at small distances from the *cross-course*. In like manner, at *Wheal Budnick*, though the *cross-vein* yields but little lead ore near the *lode*, yet the tin ore in the latter, at small distances from the *cross-vein*, is also mixed with galena.

On the other hand, the *cross-veins* at *The Consolidated* and *United Mines*, at *Ting Tang*, *Wheal Friendship*, and *Chambers's eastern flucan* in *Herland*, yield only copper and its ores, and these merely whilst in immediate contiguity with the copper *lodes*. To the occurrence of blende in *Trevaskus* and *North Downs*, the same remark applies.

Thus it seems that when in the vicinity of *lodes* the *cross-veins* occasionally contain ores, they are, for the most part, such only as these *lodes* themselves afford. Whilst in the few examples where *cross-veins* contain ores different from those which characterize the *lodes*, the latter, near their intersections, are impregnated with the ores which prevail in the *cross-veins*. Thus, wherever any metallic minerals are dispersed, each vein contains traces of the ores in the neighbouring veins; and, accordingly, the same rule prevails with regard to their metallic contents, which has already been seen to hold good of their earthy ingredients; viz., that the composition of the veins partakes of the mineral character of the rocks (and we may also add of the veins) which they traverse.

The *cross-vein* at *Beam* yields tin ore whilst traversing the granite; but all the other *cross-veins* affording metallic minerals do so whilst intersecting either the slate rocks, or the *elvan-courses* which range through them.

It has been a fact long known, and generally acted on by practical miners, that if a *lode* be *heaved* by a *cross-vein*, traces of the mineral composition of the *lode* will frequently occur in the part of the *cross-vein* interposed between the *heaved* portions of the *lode*.[1] In many instances this affords a good guide for the pursuit of the *lode* on the opposite side of the *cross-vein*. Though frequent, it is not, however,

[1] Mr. Pryce, Mineral. Cornub., p. 99: Mr. Carne, Corn. Geo. Trans., ii. p. 116: Mr. R. W. Fox, Report Royal Corn. Polytech. Soc. (1836), p. 89.

a constant occurrence; and as the circulation of water through the quartzose portions of the *cross-reins*, which are porous, softens the rock for some distance on either side of them, and renders it more easily and expeditiously penetrable, the *cross-cuts*[1] which are extended in search of *lodes* are generally excavated on the *cross-veins*. But, beside their quartzose portions, the *cross-veins* almost invariably contain clay *(flucan)*, which is usually arranged on one side or the other of the quartz, and forms a smooth face. These surfaces of clay usually cover and conceal those parts of the *lodes* which are in immediate contact with the *cross-veins;* and, indeed, at the points where they touch, the mineral characters of the *lodes*, often gradually assume some resemblance to those of the *cross-veins*. It is therefore evident that if the *cross-cuts* be *driven*[1] solely through the *cross-veins*, the miner will often proceed without recognizing the *lodes* through which he has passed. To obviate this risk of mistake it is usual to excavate *cross-cuts* partly on the courses of the *cross-veins*, and partly through the contiguous rocks, which are often softer: by which a double advantage is gained; for the expense is reduced, and the *lodes* intersected are necessarily discovered.[2]

The appearances of the rocks which form the opposite *walls* of *cross-veins* might here be considered; but, as this would involve the discussion of

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[1] *Ante*, p. 6, *note*.

[2] Mr. Pryce, Mineral. Cornub., p. 98: Mr. Thomas, Report, p. 25.

the *heaves* of *lodes*, for the sake of convenience I reserve it for another part of this Memoir.

II.—*The size or breadth of the cross-veins.*

The *cross-veins* have commonly a characteristic or prevailing size, and their changes are gradual and within very narrow limits. Their dimensions also are in general much more constant than those of the *lodes:* but to this rule there are many exceptions; for, in *Wheal Vor*, the *eastern cross-course* at 40 fathoms is 3 feet wide; at 140 fathoms it splits into two veins, one of which, at 170 fathoms deep, is 8 feet, and the other 3 fathoms, wide. Several *cross-veins* which appear at one depth are not observed at another, even in the same mine.[1] Thus, the *flucan* in *Marazion Mines* is not visible at 27 fathoms, but at 37 fathoms deep it is 4 feet wide; at *Godolphin* the *cross-course* is a mere joint in the slate rock at 60 fathoms, and at a less depth there is no trace of it, whilst, at 70 fathoms, it varies from 2 to 3 feet in breadth; at *Relistian* the *flucan* is found (though nowhere more than 4 inches wide) at all points between 75 and 125 fathoms deep, but then it entirely disappears. In *Polladras Downs* the *flucan heaves Bissa, Pressure north* and *south*, and *Richards's, lodes* at 13, 33, 43, and 53 fathoms, where it is about 2 feet wide; it, however, does not touch the *Engine lode* at less than 73 fathoms, but still deeper it *heaves* this *lode* as well as all the others, and is from 1 to 8 feet in breadth.

[1] Mr. Thomas, Report, p. 35.

Some *cross-veins* intersect certain *lodes* at all depths, but do not extend to other *lodes* at very short distances: at *Wheal Buller* two *flucans* and a *cross-course* which cut through *Davey's lode* do not reach to the *north lode;* on the other hand, a single *cross-course* occurs at the latter which does not continue to the former.

Few, if any, alterations in size seem to attend the passage of *cross-veins* from one kind of rock into another.

From *Table* CIV. it appears that the *cross-veins* which occur in the granite are, on the average, larger than those in the slate: they are also wider below 100 fathoms deep than they are above. This increased size which prevails in them when at greater depths in the same rock, and also at all depths when those in the upper strata are compared with these in the inferior rock, may probably be dependent on the same general law.

The same Table gives the average dimensions of the *cross-veins* in the various districts. It will be seen that they present considerable differences, though the cause of these discrepances are not very obvious.

III.—*The dip of the cross-veins*

Is generally less variable than that of the *lodes;* still it is so irregular that, as in them, no straight line can be drawn through the vein itself to connect distant parts at different levels.

Table CIV.

BREADTH OF THE *GUIDES, TRAWNS,* OR *CROSS-COURSES* AND *FLUCANS,* IN THE DIFFERENT DISTRICTS.

Districts.	Less than 100 fms. deep. Feet.	More than 100 fms. deep. Feet.	In Granite. Feet.	In Slate. Feet.	General Average. Feet.
Saint Just.....	3·0	..	3·2	2·75	3·0
Saint Ives.....	14·0 *	5·5	15·4 *	7·8 *	12·9 *
Marazion	2·65	..	..	2·65	2·65
Gwinear, &c. ..	1·08	0·84	..	1·0	1·0
Helston	3·7	2·51	2·51	3·65	3·06
Camborne, &c..	1·77	1·18	1·4	1·47	1·48
Redruth, &c. ..	1·69	1·44	1·17	1·74	1·62
Saint Agnes ...	2·7 †	3·80†	..	2·76†	2·76†
Saint Austell ..	4·53†	1·5 §	2·75‖	4·8 †	4·15†
Tavistock, &c. .	4·55†	19·0 ‡	8·5 **	7·67†	7·76†
Mean..	3·96	4·47	5·0	3·62	4·03

* There are a few *trawns*, each of several fathoms wide, in this district, and more particularly in the granite.

† There are several unusually large *cross-courses* in this tract.

‡ A solitary instance, at *Wheal Friendship.*

‖ One only, at *Beam.*

§ One only, at *Fowey Consols.*

** A single case, at *Birch Torr.*

DIP OF THE *GUIDES, TRAWNS*, OR *CROSS-COURSES* AND *FLUCANS*, AND WHETHER TOWARDS OR FROM THE MAIN BODY OF THE NEAREST GRANITE.

Districts.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Perpendicular.	Towards Granite.	From Granite.	Perpendicular & doubtful.
Saint Just	..	..	1	3	..	1	1	1	1	5	2	1
Saint Ives	..	..	1	..	..	3	10	..	..	13	1	..
Marazion	..	3	3	..	..	..	1	..	..	3	1	3
Gwinear, &c.	1	2	10	..	1	..	13	3	3	15	15	3
Helston	1	..	3	..	1	..	7	..	3	8	3	4
Camborne, &c.	..	..	6	..	..	2	6	..	6	8	6	6
Redruth, &c.	1	2	19	..	..	1	4	..	7	7	19	8
Saint Agnes	..	3	7	2	..	2	3	..	1	10	7	1
Saint Austell	..	..	3	1	..	1	..	..	2	1	3	3
Tavistock, &c.	1	1	2	..	..	..	5	..	..	5	4	..
Total....	4	11	55	6	2	10	50	4	23	75	61	29

Table CV.

From *Table* cv. it appears that, in 165 examples, 4 dip N., and 2 S., whilst 72 incline towards points E. of a meridian line, and 64 to the W. of it, and there are 23 of them perpendicular; whilst 75 of them dip towards, and 61 from, the granite, and there are 29 doubtful cases. These particulars shew so trifling a preponderance on either side, that no inference can be drawn from them.

To whatever point the *cross-veins* may incline, the amount of their inclination from the horizon is on the whole considerably greater than that of the *lodes*, and, on an average, is probably little, if at all, less than 80°; although there are many exceptions to it, as at *Wheal Darlington, Wheal Falmouth,* &c.

The *cross-veins,* like the *lodes,* are usually tolerably constant in the direction of their *underlie,* though its amount may differ: thus, as a general fact, those which dip either E. or W. seldom, in any part of their courses, have their inclination reversed. But, though this is the prevailing rule, there are a few exceptions to it in almost every district; as, for example, in *Wheal Spearn, Wheal Union, Relistian, Stray Park,* &c.

It has been already seen[1] that though the composition of the *cross-veins* depends on that of their containing rocks; yet, *cæteris paribus,* they present in this respect much greater uniformity than the *lodes.* The *lodes* alter their composition with change of dip and size: the *cross-veins,* on the contrary, seem to be not at all affected in their composition or

[1] *Ante,* p. 265.

structure by a change in either inclination or bulk Neither does the passage of *cross-veins* from one kind of rock into another seem to affect the genera amount of their dip: thus, at *Cook's-kitchen* the *little cross-course* passes from slate into granite; a *Tincroft* the *eastern cross-course* is also seen in both of these rocks, and likewise in *elvan*; the *flucans* in *Ting Tang, Wheal Unity Wood, Cardrew Downs* and *Polgooth*, intersect slate and *elvan*, which rocks are also traversed by *cross-courses* at *The United* and *Consolidated Mines, Wheal Devonshire*, and *Wheal Prudence*, but in none of these instances do the *cross-veins* alter their dip.

At *Wheal Vor, Wheal Friendship*, and other places, the *cross-veins* divide into branches, which spread out and rival, or even exceed, in size the veins from which they spring, or into which they converge. When they divide as they descend, there must, of course, be an attendant alteration in the dip of the one part or the other: but, even in this case no causes, either in the veins themselves or in the intersected rock, have been ascertained to concur in producing these changes. Our ignorance, indeed, of the cause probably depends on the circumstance that the components of the *cross-veins* have attracted little attention, as they are so seldom prolific in metallic ores.

IV.—*Directions of the cross-veins.*

Table CVI. indicates the bearings of the various *cross-veins*, and from it their mean directions in the different districts are here deduced: viz.—

DIRECTIONS OF THE *GUIDES, TRAWNS,* OR *CROSS-COURSES* AND *FLUCANS,* IN THE DIFFERENT DISTRICTS.

Districts.	N. to 10° W. of N.	10-20° —	20-30° —	30-40° —	40-50° —	50-60° —	60-70° —	70-80° —	80° W. of N. to W.	W. to 10° S. of W.	10-20° —	20-30° —	30-40° —	40-50° —	50-60° —	60-70° —	70-80° —	80° S. of W. to S.
Saint Just.....	..	1	1	..	..	..	..	..	..	..	..	..	1	..	3	..	2	..
Saint Ives.....	1	2	1	1	6	..	..	..	..	..	..	..	..	..	..	2	..	..
Marazion	1	..	2	2	..	1	..	..	..	..	..	..	..	..	..	..	1	..
Gwinear, &c. ..	8	3	9	2	4	..	1	1	..	..	..	1	..	1	..	1	1	1
Helston	..	3	4	1	1	1	..	..	1	..	..	..	..	..	..	1	..	3
Camborne, &c. .	9	..	4	2	1	1	..	..	..	..	..	..	..	..	..	..	2	..
Redruth, &c. ..	4	6	6	6	4	..	1	..	..	..	..	1	..	..	1	4	..	2
Saint Agnes ...	3	3	2	4	3	..	..	..	..	..	..	..	1	..	..	1	..	..
Saint Austell ..	2	1	..	..	..	..	1	..	..	..	..	..	1	2	..	..	..	..
Tavistock, &c. .	3	1	1	..	..	..	3	..	..	..	..	..	..	..	..	..	..	1
Total....	31	20	30	18	19	3	6	1	1	0	0	2	3	3	4	9	6	7

Table CVI.

Saint Just — — — —	26° S. of W.
Saint Ives — — — —	38° N. of W.
Marazion — — — —	41° N. of W.
Gwinear, &c. — — —	43° W. of N.
Helston — — — —	21° N. of W.
Camborne, &c. — — —	34° W. of N.
Redruth, &c. — — —	35° N. of W.
Saint Agnes — — —	39° W. of N.
Saint Austell — — —	21° N. of W.
Tavistock, &c. — — —	43° N. of W.
The mean of the whole being	38° N. of W.[1]

On a comparison of this result with *Table* XCIX., it will be seen that this average only differs a few degrees from that of one of the best and most distinctly developed series of joints in the rocks.

The *cross-veins* exhibit in their horizontal bearing flexures and curvatures similar to, but in general to a smaller extent than, those which have been already noticed in the *lodes*.[2] There are, however, a few instances in which the same *cross-vein* takes widely different directions in different parts of its course at the same level, as in *Skues's flucan* in *Poldory (United Mines)*, where the difference amounts to 40°. At different levels, too, the bearings of the same *cross-vein* sometimes materially alter, as in *Wheal Providence*, where the amount of discord-

[1] Mr. Hutchinson, quoted by Dr. Borlase, Natural History, p. 156: Mr. Pryce, Mineral. Cornub., p. 98: Mr. Tonkin's Notes, published by Lord De Dunstanville in his edition of Carew's Survey of Cornwall, p. 36: Dr. Berger, Geo. Trans., o.s. i. p. 165: Mr. Wm. Phillips, Ibid, ii. p. 133: Mr. Thomas, Report, p. 21: Mr. Carne, Corn. Geo. Trans., ii. pp. 85–108–109–114.

[2] *Ante*, p. 174.

ance is nearly 90°. But these are extreme examples of the irregularities in their courses, and are almost singular exceptions to the general rule. The Saint Just district is the only one in which the mean direction of the *cross-veins* is to the east of north; whilst the average bearings in all the other districts are to the west of north: for, notwithstanding there are in some of them a few individual instances in which they bear east of the meridian, the preponderance of the directions west of it is so great that the former entirely disappear in the averages. The difference between the mean direction of this class of veins in the Saint Just district[1] and that of those in the Helston and Saint Austell districts, which approach the nearest to it, is 47°; whilst the greatest discordance between those in the other tracts is no more than 35°, and this occurs between the *cross-veins* in the Camborne and those in the Helston and Saint Austell tracts.

The differences in their directions seem to be altogether independent of the nature of the rocks: for, though greenstone prevails in the Camborne district, and clay-slate forms the greater part of that of Saint Agnes, the average bearings of their *cross-veins* coincide within 5°. Again, granite prevails throughout the Saint Ives district, whilst near Marazion clay-slate is (with the exception of some *elvan-courses)* the only rock, yet the difference in the directions of their *cross-veins* is not more than 11°.

[1] The only difference besides that of direction which characterizes the Saint Just *cross-veins*, is the much greater prevalence of iron ores in them than in the others.

At *Poldory, Wheal Providence,* and the few other localities in which the same *cross-veins* undergo remarkable changes in their bearings,[1] there are no discoverable alterations, either in the characters of the rocks, or in the mineral composition of the veins themselves.

THE SLIDES

Are the only class of veins of which it now remains to speak. These are so few, that their general characters may be exhibited more clearly at one view, than under the subdivisions which have been thought necessary for the *lodes* and *cross-veins.*

MINE.	*DIRECTION.*	*DIP.*	*SIZE.*
Gwallon — —	25° W. of N. —	W. —	4 ins.
Herland — —	S.E. & N.W. —	N.E. —	6 „
Wheal Vor —	E. & W. —	S. —	9 „
Binner Downs —	25° S. of W. —	N. —	4 „
Wheal Unity Wood,	25° S. of W. —	N. ? —	12 „
Great St. George,	35° S. of W. —	S.E. —	10 „
Wheal Kayle —	N.E. & S.W. —	N.W. —	2 „
Penwinnick —	N.E. & S.W. —	S.E. —	4 „
Duffield — —	10° W. of S. —	W. —	7 „

To which, probably, may be added the *flucan* in *Polgooth,* which bears N.E.& S.W., is perpendicular, and about 9 inches wide.

From these particulars it will be evident that there is no great coincidence in their directions,[2] or dips. In the examples before us four dip from the

[1] *Ante,* p. 53, *note.*† [2] Mr. Carne, Corn. Geo. Trans., ii. p. 119

nearest granitic mass: the dip of the remainder is indeterminate, but neither of them has a decided inclination towards the granite.

It is not unworthy of notice that all those hitherto observed occur in the slate series,[1] and intersect only the schistose rocks and the *elvans*, and other veins traversing them; whilst there is not a single well marked instance of a *slide* in the granite,[2] or the massive rocks of the slate formation, yet known in any part of Cornwall.

None of the *slides* are metalliferous; and their whole substance consists of soft clay, similar, in mineral composition, to the rocks which they traverse. So close, indeed, is this resemblance, that even the lamination of the slate is often as perfect in them as in the contiguous rock, and its position is the same in both; so that the softness of the *slide* is frequently the only character which distinguishes it from the neighbouring *country*, as at *Gwallon*, *Duffield*, and *Wheal Kayle*.

The breadth of *slides* is generally very small; seldom, in fact, exceeding one foot.[3]

Like those of all other veins their inclinations are irregular and subject to frequent changes: generally, however, they are less inclined to the horizon than any other class of veins; for, at *Binner Downs* and

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1 "The slides which came under notice in this survey, are all formed of "clay, and are in killas ground." MR. THOMAS, *Report*, p. 21.

2 At *Wheal Vyvyan* (*ante*, p. 73), certain granitic veins which traverse the granite have the same effects as *slides* in *throwing* some of the small metalliferous strings by which the granite of that locality is intersected.

3 Mr. Carne, Cornwall Geo. Trans., ii. p. 119.

Wheal Kayle, the *slides* are nearly horizontal; but, in other cases, as *Wheal Vor* and *Great Saint George,* they have more inclination. The average of their underlie may, perhaps, not be far from 40° or 45°.[1]

Though in their directions they have little uniformity, yet, in this respect, they closely resemble the *lodes* in their respective neighbourhoods: but, differing in their inclinations, they intersect them as they descend. These results are, consequently, shown by transverse sections, whilst the horizontal intersections of *lodes* and *cross-veins* are exhibited by plans.

This, however, is true, only so long as a perfect parallelism in direction prevails: for, if this ceases, a plan, as in the case of a *cross-vein,* will also be requisite for its intelligible delineation. The difficulty of determining whether the veins of clay, which are nearly, but not perfectly, parallel to the *lodes* in direction, should be classed as *cross-veins* or *slides,* has probably led to the somewhat confused phraseology of practical miners, which often groups them together, or arbitrarily separates them.[2]

THE INTERSECTIONS OF VEINS.

The different directions and frequent changes in

1 "The dip or inclination (of slides) from the horizon (is) between 25 and "35 degrees: they may be considered as lodes of clay having a great underlay." MR. THOMAS, *Report,* p. 21.

2 It has been already stated (*ante,* p. 159) that the mining nomenclature of rocks is not very precise; that of the veins, it may here be added, is not always more exact, for the terms *flucan* and *slide* are often employed synonymously.

"Flookans, called Slides." MR. PRYCE, *Mineral. Cornub.,* p. 107.

the inclination of veins necessarily give rise to numerous intersections, both horizontal and vertical, alike occurring in their courses and their dips.

I.—HORIZONTAL INTERSECTIONS.

The enquiry respecting these may be conducted in the following order: viz.—(1) the composition of the intersected vein; (2) and also of that intersecting it; (3) the nature of the containing rock; (4) the width of the intersected vein; and (5) likewise of the vein intersecting; (6) the angles horizontally included between the veins; (7) the inclinations of the veins; (8) whether the *heaves* are of similar extent at all depths; and (9) whether the *heave* of *one* vein by *another* be in the same direction, and for the same distance, at all levels; (10) when *one* vein is in different parts of its course intersected by *several others*, whether all the *heaves* it may thus present are similar in direction and extent; (11) when *the same* vein traverses *several others*, whether it *heaves all* of them an equal distance, and in the same direction; (12) whether a vein, which intersects another in one spot, is ever, in another place, itself intersected by a vein similar to that which it had traversed.

The determination of the questions here stated will apply equally to (*a*) the intersections of *lodes* by *cross-veins*; (*b*) to the intersections of *cross-veins* by *lodes*; and (*c*) to the interferences of *lodes* with each other.

These divisions will include the majority of cases; but some will still remain, whose obscure and ill-defined character will not permit us to refer them with confidence to either of them.

The result of every intersection must be either a simple cutting through of one vein by the other; or, what is called by miners a *heave*, and, in the language of theory, a dislocation or displacement. In the former case the portions of the intersected vein occur exactly opposite to each other on either side of the intersecting vein. In the latter this is not the case, but when the traversing vein is approached along the course of one of the severed parts, the other is found by turning towards the *right* or *left* hand.[1] By this concise mode of expression, rather than by the points of the compass, it is usual to mark the nature of the *heave*. I need not here re-state the meaning affixed to the terms *greater* and *smaller angle*, which have been already defined.[2]

A comparison of the facts detailed in the preceding pages with these conditions will indicate which, if any, of them affect the results; and, also, inform us whether any general rule founded on them is applicable to any class of veins, or to any description of rock. And, further, this enquiry will supply *data* for determining whether the portions of the same *lodes* on opposite sides of *cross-veins* possess such a similarity of outline, or distance from, or dependence on, any well marked peculiarity, either

[1] *Ante*, p. 5. [2] *Ante*, p. 6.

of structure, size, or inclination, as will lead to an practical or certain conclusions.

1. ***Relations between the contents of intersecte veins, and the results of their intersections.***—

(*a.*) ***Intersections of lodes, affording different ore by cross-veins.***—***Table*** CVIII. exhibits the results o 233 intersections, of which 50 are of *lodes* yieldin tin ores only, 59 of *lodes* in which the ores of ti and copper occur together, and 124 of *lodes* afford ing copper ore alone. 53 of these intersections ar simple and unattended by *heaves:* of the remainde 119 are *heaved* towards the right hand, and 61 to wards the left; 150 to the greater, and 30 to th smaller angle.

The relative proportions of the various phenomen are as follow: viz.—

Of all the *lodes*, the proportion intersected but not *heaved* is	22·7	℔ cent.
Of the tin *lodes*, ,, ,, ...	18·0	,,
,, *lodes* yielding both tin & copper ores,	37·2	,,
,, copper *lodes*, ,, ,, ...	17·7	,,
Of all the *lodes*, the proportion *heaved* towards the *right hand* is[1]	51·1	,,
Of the tin *lodes*, ,, ,, ...	56·0	,,
,, *lodes* yielding both tin & copper ores,	44·0	,,
,, copper *lodes*, ,, ,, ...	52·4	,,
Of all the *lodes*, the proportion *heaved* towards the *left hand* is	26·2	,,
Of the tin *lodes* ,, ,, ...	26·0	,,
,, *lodes* yielding both tin & copper ores	18·6	,,
,, copper *lodes* ,, ,, ...	29·8	,,

[1] "It is remarkable that all the principal *heaves* in the district (fr "Chacewater to Camborne) should be to the *right*, while those to the *left* "but insignificant in comparison with them." Mr. Thomas, *Report*, p. 23. Mr. Carne, Cornwall Geo. Trans., ii. p. 118.

Of all the *lodes*, the proportion *heaved* towards the *greater angle* is	63·5	℔ cent.
Of the tin *lodes*, ,, ,,	52·0	,,
,, *lodes* yielding both tin and copper ores,	56·0	,,
,, copper *lodes*, ,, ,,	74·2	,,
Of all the *lodes*, the proportion *heaved* towards the *smaller angle* is	12·9	,,
Of the tin *lodes*, ,, ,,	30·0	,,
,, *lodes* yielding both tin and copper ores,	6·8	,,
,, copper *lodes*, ,, ,,	8·8	,,
The mean distance of the *heaves* of all the *lodes* is	16·4	feet.
,, ,, tin *lodes*	15·4	,,
,, ,, of *lodes* yielding both tin and copper ores	14·6	,,
,, ,, of copper *lodes*	17·5	,,
The mean distance of the *right hand heaves* is	18·7	,,
,, *left-hand* ,,	12·0	,,
,, *heaves* toward the *greater angle*,	16·3	,,
,, ,, *smaller angle*,	17·1	,,

The more minute details are supplied by *Table* CVII., and the particulars of each individual example may be found in *Tables* I.–XCVIII.

In connexion with this subject it will be desirable to trace the same conditions occurring in the intersections of *cross-veins* by *lodes*, and of *lodes* by each other.

(1-*b*.) *Intersections of cross-veins by lodes yielding the ores of different metals.*—Twenty-three intersections of this kind have been noticed in the course of this inspection: 10 of them are unaccompanied by *heaves*, 7 are *heaved* towards the right hand, and 6 towards the left; and, of the 13 *heaves*, 10 are towards the greater, and 3 towards the smaller angle. Of the *cross-veins*, 5 are intersected by tin *lodes*, 9 by *lodes* which yield ores of both tin and copper, and 9 by copper *lodes*.

The proportions of the various results are as follow:—

Of all the *cross-veins* intersected, the proportion of those not *heaved is*	43·5	₩ cent.
Of all the *cross-veins* intersected by tin *lodes*, ,, ..	60·0	,,
,, ,, by *lodes* yielding both tin & copper ores, ,, ..	44·4	,,
,, ,, by copper *lodes*, ,, ..	33·3	,,
Of all the *cross-veins* intersected, the proportion *heaved* to the *right hand* is	30·4	,,
Of all the *cross-veins* intersected by tin *lodes*, ,, ..	40·0	,,
,, ,, by *lodes* yielding both tin & copper ores, ,, ..	11·1	,,
,, ,, by copper *lodes*, ,, ..	44·4	,,
Of all *cross-veins* intersected, the proportion *heaved* to the *left hand* is	26·1	,,
Of all the *cross-veins* intersected by *lodes* yielding both tin and copper ores,[1] ,, ,, ..	44·5	,,
Of all *cross-veins* intersected by copper *lodes*, ,, ..	22·3	,,
Of all *cross-veins* intersected, the proportion *heaved* to the *greater angle* is	43·5	,,
Of all *cross-veins* intersected by tin *lodes*, ,, ..	20·0	,,
,, ,, by *lodes* yielding both tin & copper ores, ,, ..	55·6	,,
,, ,, by copper *lodes*, ,, ..	44·4	,,
Of all *cross-veins* intersected, the proportion *heaved* to the *smaller angle* is	13·0	,,
Of all *cross-veins* intersected by tin *lodes*, ,, ..	20·0	,,
,, ,, by copper *lodes*,[2] ,, ..	22·3	,,
The mean dist. of *heaves* of *cross-veins* by *lodes* is	8·1	feet.
,, ,, by tin *lodes*	21·1	,,
,, ,, by *lodes* yielding both tin & copper ores..	5·5	,,
,, ,, by copper *lodes*	4·1	,,
The average distance of the *right hand heaves* is..	10·7	,,
,, ,, *left-hand* ,, ..	5·1	,,
,, *heaves* toward the *greater angle* is	9·0	,,
,, ,, *smaller angle*..	4·2	,,

[1] I have seen no tin *lode heave* a *cross-vein* towards the *left hand*.

[2] No *cross-vein* has been seen *heaved* towards the *smaller angle* by a *lode* yielding both tin and copper ores.

The particulars will be found in *Table* CX.; but the examples are so few that their average results are not, perhaps, entitled to much consideration.

(1-*c*.) *The intersections of lodes by each other.*—Twenty examples of this class have come under review in the course of this enquiry, of which 6 are simple intersections, 9 are *heaved* towards the right hand, and 5 to the left; 5 are *heaved* towards the larger and 9 towards the smaller angle.

The instances in which *lodes* yielding the ores of one metal, are intersected by those containing different ores, are comparatively few, since the rocks and veins, within limited areas, have a certain degree of uniformity, and, consequently, there is some general resemblance in the composition and produce of *lodes* in the same mine.

Of the 6 *lodes* intersected by others, but suffering no displacement, 2 are tin *lodes* intersected by other tin *lodes;* 4 are copper *lodes* intersected by other copper *lodes:* of the 9 *lodes* which are *heaved* towards the *right hand,* 4 are tin *lodes heaved* by other tin *lodes;* 5 are copper *lodes heaved* by other copper *lodes:* of the 5 *lodes* which are *heaved* towards the *left hand,* 1 is a tin *lode heaved* by another tin *lode;* 4 are of copper *lodes heaved* by other copper *lodes:* of the 5 *lodes* which are *heaved* towards the *larger angle,* 1 is a tin *lode heaved* by another tin *lode;* 4 are copper *lodes heaved* by other copper *lodes:* of the 9 *lodes* which are *heaved* towards the *smaller angle,* 4 are tin *lodes heaved* by other tin *lodes;* 5 are copper *lodes heaved* by other copper *lodes.*

No example of the intersection of *lodes* yieldin the ores of different metals has occurred to m notice.

The mean dist. of the *heaves* of *lodes* by other *lodes* is		29·8 fe
,, ,,	tin *lodes* ,, ..	39·0 ,,
,, ,,	copper *lodes* ,, ..	25·0 ,,
,, ,,	to the *right hand* ..	31·7 ,,
,, ,,	,, *left hand* ..	27·0 ,,
,, ,,	,, *greater angle* ..	25·0[1] ,,
,, ,,	,, *smaller angle* ..	11·0 ,,

I can assign no specific differences between th ingredients of the intersected *lodes*, and of those b which they are traversed.

2. ***Relations between the composition of the tr versing veins, and the results of their intersections.***–

(*a.*) ***Intersections of lodes affording different ore by cross-veins of different compositions.***—It has bee already remarked, that as throughout tracts of sma extent the composition of the rocks is usually, i some measure, uniform, so the *lodes*, within any suc given tracts, are nearly the same in their character This general fact may be applied with even mo certainty to the *cross-veins*, whose characters a still more uniform: for they consist, as we have see for the most part, of quartz and clayey portions the contiguous rocks;—and, with the exception lead ores, and these not abundant, the metallic ma ters which they contain are in small quantities, a dispersed through very limited portions of them.

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[1] A *heave* of 144 feet at *Wheal Bellon*, and another of 100 feet at *Dolcoa* are omitted: their insertion would have raised this average to 64 feet inst of 25.

Of the 233 intersections before particularized, 125 are by clayey *cross-veins (flucans)*, and 108 by quartzose ones *(cross-courses)*, being 53·7 per cent. by the former, and 46·3 by the latter.

(*a*-1.) Of the 125 intersections by *flucans*—

Those unaccompanied by *heaves* are.....	22 or 17·6	℔ cent.
,, *heaved* towards the *right hand*	69 ,, 55·2	,,
,, ,, *left hand*.....	34 ,, 27·2	,,
,, ,, *greater angle*	88 ,, 70·4	,,
,, ,, *smaller angle*	15 ,, 12·0	,,
Of the 103 *lodes heaved* by *flucans*—		
The tin *lodes* are	25 ,, 24·2	,,
,, *lodes* yielding both tin and copper ores..	6 ,, 5·8	,,
,, copper *lodes*	72 ,, 70·0	,,
Whilst of the 22 *lodes* which are intersected by *flucans*, without being *heaved*—		
The tin *lodes* are	3 ,, 13·6	,,
,, *lodes* yielding both tin and copper ores..	13 ,, 59·1	,,
,, copper *lodes*	6 ,, 27·3	,,
Of the 28 tin *lodes* which are intersected by *flucans*—		
Those which are *heaved* are.....	25 ,, 89·3	,,
,, not *heaved*.....	3 ,, 10·7	,,
Of the 19 *lodes* affording both tin and copper ores, and intersected by *flucans*—		
Those which are *heaved* are	6 ,, 31·6	,,
,, not *heaved*.....	13 ,, 68·4	,,
Of the 78 copper *lodes* which are intersected by *flucans*—		
Those which are *heaved* are.....	72 ,, 92·3	,,
,, not *heaved*.....	6 ,, 7·7	,,

The mean distance of all the *heaves* by *flucans* is....	21·5 feet.
,, of the *heaves* of tin *lodes*.....	19·3 ,,
,, ,, *lodes* yielding both tin & copper ores	16·5 ,,
,, ,, copper *lodes*	22·7 ,,
The aver. dist. of *heaves* by *flucans* to the *right hand* is	24·4 ,,
,, ,, ,, *left hand* ..	15·3 ,,
,, ,, ,, *greater angle*	21·7 ,,
,, ,, ,, *smaller angle*	20·2 ,,

(*a*-2.) Of the 108 intersections by *cross-courses* (quartzose *cross-veins*)—

Those unaccompanied by *heaves* are.....	31 or 28·7	per cent.
„ *heaved* towards the *right hand*	48 „ 44·4	„
„ „ *left hand*	29 „ 26·9	„
„ „ *greater angle*	64 „ 59·3	„
„ „ *smaller angle*	13 „ 12·0	„
Of the 77 *lodes heaved* by *cross-courses*—		
The tin *lodes* are	15 „ 19·5	„
„ *lodes* yielding both tin and copper ores..	32 „ 41·5	„
„ copper *lodes*	30 „ 39·0	„
Of the 31 *lodes* which are intersected by *cross-courses*, without being *heaved*—		
The tin *lodes* are	7 „ 22·6	„
„ *lodes* yielding both tin and copper ores..	9 „ 29·0	„
„ copper *lodes*	15 „ 48·4	„
Twenty-two tin *lodes* are intersected by *cross-courses*, and of them—		
Those which are *heaved* are...	15 „ 68·2	„
„ not *heaved*...	7 „ 31·8	„
Forty-one *lodes*, in which tin and copper ores are mixed, are intersected by *cross-courses*, and of them—		
Those which are *heaved* are	32 „ 78·0	„
„ not *heaved*	9 „ 22·0	„
Forty-five copper *lodes* are intersected by *cross-courses*, of which—		
Those which are *heaved* are	30 „ 66·7	„
„ not *heaved*	15 „ 33·3	„
The average dist. of all the *heaves* by *cross-courses* is	10·5	feet
„ of the *heaves* of tin *lodes*	12·6	„
„ „ of the *lodes* yielding both tin and copper ores ..	14·1	„
„ „ of copper *lodes*	6·1	„
The mean dist. of *heaves* by *cross-courses* to *right hand* is	12·3	„
„ „ „ *left hand* ..	7·1	„
„ „ „ *greater angle*	9·3	„
„ „ „ *smaller angle*	16·3	„

It is a remarkable but well-known fact, that th extent of the *heaves* by *flucans* is much greater tha

of those by *cross-courses.* It is also not unworthy of notice, that the *flucans heave* the copper *lodes* further than they do the other *lodes,* whilst the *cross-courses heave* them much less. The right-hand are larger than the left-hand *heaves,* both by *flucans* and *cross-courses:* but, with the former, the *heaves* towards the larger angle are greater than those towards the smaller angle; whilst, with the latter, the *heaves* to the smaller are of much greater extent than those to the larger angle.

(2-*b.*) *Intersections of cross-veins of different compositions, by lodes yielding the ores of different metals.*—

It has been already stated[1] that in the course of this enquiry 23 *cross-veins* have been seen *heaved* by *lodes* of different kinds: of these, 12, or 52·2 per cent., are clayey veins *(flucans),* and 11, or 47·8 per cent., quartzose *(cross-courses).*

(*b*-1.) Of the cases in which *flucans* are intersected—

Those unaccompanied by *heaves* are	6 or 50·0	per cent.
„ *heaved* towards the *right hand*	3 „ 25·0	„
„ „ *left hand*.....	3 „ 25·0	„
„ „ *greater angle*	5 „ 41·7	„
„ „ *smaller angle*	1 „ 8·3	„
Of the 6 *flucans* intersected but not *heaved* by *lodes*—		
There is intersected by a tin *lode*	1 „ 16·6	„
There are „ *lodes* yielding both tin and copper ores....	2 „ 33·4	„
„ copper *lodes*	3 „ 50·0	„
Of the 6 *flucans* which are *heaved* by *lodes*—		
Those by *lodes* affording tin & copper ores are	3 „ 50·0	„
„ copper *lodes*	3 „ 50·0	„

I have seen no *flucan heaved* by a tin *lode.*

[1] *Ante,* p. 287.

The mean dist. of all the *heaves of*
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ti
,, ,, by
The average distance of *heaves* of
to th
,, ,, ,,
,, ,, ,,
,, ,, ,,
(*b*-2.) Eleven *cross-courses* (quartzos
lodes, of which those unattended by
,, *heaved* to the
,, ,,
,, ,, *gre*
,, ,, *sm*
Of the 4 *cross-courses* which are i
but not *heaved*—
There are intersected by tin *lodes* ..
,, *lodes* yieldi
and copp
I have seen no simple intersection of
Seven *cross-courses* are *heaved* b
heaved by tin *lodes*.....
,, *lodes* yielding tin & cop
,, copper *lodes* .....
The mean dist. of all the *heaves* of *cr*
,, ,,
,, ,,
,, ,,
The average distance of *heaves* of *c*
t
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,, ,,

[1] I omit the *heave* of 60 feet at *West Pi*
distance would have been 14·6 feet; th
lodes, and of *right-hand heaves*, 24·3 feet
angle, 15·8 feet.

[2] A single instance at *Dolcoath*.

It will be observed, that whilst the mean distance of the *heaves* of *lodes* by *flucans* is considerably greater than of those by *cross-courses*, the *heaves* of *flucans* by *lodes* are also greater than those of the *cross-courses*:—a fact which will be more fully developed in another part of this investigation.

(*c.*) *The intersections of lodes of different compositions* have been already discussed.[1]

(*d.*) *Intersections of cross-veins of different compositions by each other.*—

I have met with but a single case in which one *cross-vein* intersects another.[2] This occurs at *Polladras Downs*, where the quartzose vein is intersected by the clayey one (the eastern *flucan* intersects the *cross-course*), but without any displacement.

I have seen no instance of a *flucan* being intersected by a *cross-course*.

3. *Relations between the rocks and the intersections of the veins which traverse them.*—

(*a.*) Of the 233 intersections of *lodes* by *cross-veins* which have been so often referred to, 61 (26.1 per cent.) occur in granite, and 172 (73.9 per cent.) in slate.[3] From the difficulty of enquiry and its uncertainty, I cannot state whether the difference between these numbers depends merely on the much greater area occupied by the slate than by the granite in the tracts here considered, or whether the

[1] *Ante*, p. 289.

[2] Mr. Thomas states that Skewes's Flucan intersects the Great Cross-course of *Wheal Damsel*. Report, p. 53. Mr. Carne confirms this, and also mentions a similar occurrence at *Wheal Alfred*. Corn. Geo. Trans., ii. p. 110.

[3] Two of this number occur in *elvan* at *Ting Tang*.

intersections of veins are really more common in on rock than in the other, under conditions otherwis similar.

If we regard the total numbers in each rock a 100, then the respective proportions will be as fo low: viz.—

	In *granite.*	In *slate.*
The intersections, without *heaves*..	26·2 ℔ cent.	21·5 ℔ cen
Heaves toward the *right hand*....	52·4 ,,	50·5 ,,
,, *left hand*	21·4 ,,	28·0 ,,
,, *greater angle*..	65·6 ,,	64·0 ,,
,, *smaller angle*..	8·2 ,,	14·5 ,,

The mean distances of all the *heaves* is ..... 16·4 feet
,, ,, in granite ..... 17·1 ,,
,, ,, slate ..... 16·3[1] ,,

The relative proportions seem scarcely sufficien to warrant the idea that the slight difference between them have much connexion with the natur of the containing rock.

It has been seen[2] that the 233 intersections ar effected by 125 veins of clay, or *flucans*, and 10 quartzose ones, or *cross-courses*. The proportion in which they occur in the different rocks are—

	In *granite.*	In *slate.*
Flucans	78·7 ℔ cent.	47·0 ℔ cent.
Cross-courses	21·3 ,,	53·0 ,,

This result is in accordance with the general fac long recognized in some parts of Cornwall:—tha the *cross-veins* far more frequently partake of th nature of the contiguous rock (and are thus chara terized as *flucans)* in the granitic than in the sla

[1] The average distance of the two *heaves* in the *elvan* at *Ting Tang* is 14·5 fe
[2] *Ante*, p. 291.

rocks; and that in the latter they are much more generally quartzose in their composition, and are thus designated *cross-courses.*

(*b.*) The intersections of *cross-veins* by *lodes* are 23 in number; of these 36 per cent. are in granite, and 64 per cent. in slate.

(*c.*) Twenty instances of *lodes* intersected by other *lodes* have been here recorded, of which 20 per cent. are in granite, and 80 per cent. in slate.

The general approximation in the proportions of the various results of the intersections in these smaller and less material classes of facts, to those in the larger and more important division, is such, that it scarcely seems desirable to pursue them into the more minute subdivisions. Further details will, however, be found in *Tables* CX.–CXI.

4. *On the influence the breadth of the traversing veins may have on the extent of the heaves they produce.—*

Whether the breadth of a *cross-vein* influences the distance to which it may *heave* the *lodes* intersected by it, or whether, when it is wider or narrower, the proportion of simple intersections in the *lodes* traversed is increased or diminished, is one of the most interesting parts of this enquiry; and, to determine it, we have no guide but observation.

Individual examples may doubtless be selected from the foregoing details which would give a colour to opposite views; but the truth can only be obtained by a statement of the general average.

Were our facts distributed, as before, in many

classes, a few examples of *heaves* to a great exten in one, or to a small distance in another, would caus an undue preponderance, and entangle us in diff culties. It has, therefore, been thought best to forı but two classes: viz.,—1st, the *heaves* by *cross-vein* of less than 1 foot in width; and, 2nd, those b *cross-veins* which are more than 1 foot broad.

The respective results are that—

The proportion of intersections by *cross-veins*, of less than 1 foot wid		
which are unattended by *heaves* is.....	30·4	per cent
,, more than 1 foot wide ,, ...	20·3	,,
The average distance of the *heaves* by *cross-veins*—		
less than 1 foot wide, is.....	12·5	feet
,, more than 1 foot wide	23·0[1]	,,

This difference, both in the proportion of th simple intersections to total number, and also in th respective average distances of the *heaves*, seem strikingly to show that some relation must exis between the width of the *cross-vein* and the intensit of its disturbing force, whatever that may be, on th veins it intersects.[2]

For the reasons already given, I prefer this gen ral announcement to an enumeration of particul examples.

5 *On the relations between the breadth of the inte sected veins and the results of their intersections.*—

The remarkable fact just disclosed naturally lea us to enquire whether the dimensions of the *lod*

[1] The *heaves* at *Wheal Providence* and *Polgooth* are not included in t average.

[2] "I apprehend the heave is, cæteris paribus, in proportion to the size of " Flookan or Slide." Mr. Pryce, *Mineral Cornub.*, p. 106.
Mr. Carne, Cornwall Geo. Trans., ii. p. 117.

influence the distances of their *heaves*. As, however, the *lodes*, less than one foot wide, are very few, in order to place a sufficient number of examples in each class, it becomes necessary to make a breadth of two feet the line of demarcation between them.

The mean distance of the *heaves* of *lodes*, which are

less than 2 feet wide, is	9·1	feet.
,, more than 2 feet wide	24·6	,,

The intersections unaccompanied by *heaves* are,

of *lodes* less than 2 feet wide	26·2	℔ cent.
,, ,, more than 2 feet wide	23·6	,,

The difference between the proportions of simple intersections, whether of large or small *lodes*, is so trivial as to require no further remark.

On the contrary, the difference between the extent of the *heaves* of large and of small *lodes* is so great, and indeed so much greater than that of the *heaves* by large and by small *cross-veins*, as to suggest the probability that the dimensions of the *lodes* exert an influence at least as great as that of the *cross-veins* on the result of their intersections: and also that, in this respect, some mutual dependance, or necessary connexion, subsists between them, and jointly affects the extent of the *heaves*. The facts, also, seem to indicate that this is in a direct, rather than in an inverse proportion.

If this be true, it will follow that the intersections of large *lodes* by large *cross-veins* should present a maximum extent of *heave*, and those of small *lodes* by small *cross-veins* a minimum; whilst those of a large and a small vein of either kind should afford

nearly a mean: differing, indeed, in either case, from a true arithmetical mean, only inasmuch as that the influence of the width of the *lodes* being apparently greater than that of the *cross-veins*, the intersections of large *lodes* by small *cross-veins* should exhibit a somewhat higher average than those of small *lodes* by large *cross-veins*.

These views receive a most complete and decisive confirmation by the facts: for the mean distances of the various *heaves* are as follow: viz.—

Of large *lodes* by large *cross-veins*,[1]	28·3 feet.
„ small „ „	16·1 „
„ large *lodes*, by small *cross-veins*, ...	17·0 „
„ small „ „	4·8 „

The proportions of simple intersections, unattended by *heaves*, are—

Of large *lodes*, intersected by large *cross-veins*,	34·6 ℔' cent
„ small „ „ „ ..	18·0 „
„ large *lodes*, intersected by small *cross-veins*,	28·3 „
„ small „ „ „ ..	23·8 „

Any general law that may rule these simple inte sections is by no means apparent: and, as they a cases which present neither doubt nor difficulty the miner, they seem to require no further comme

(*b.*) *The relations between the heaves of lodes, a the angles included at their intersections by cro veins.*—

In *Table* CVIII.[2] these are exhibited under all t conditions of their occurrence in the different roc

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[1] By small and large *lodes* are meant, respectively, those less and greater t two feet in breadth:—by small and large *cross-veins*, such as are of large smaller breadth than one foot.

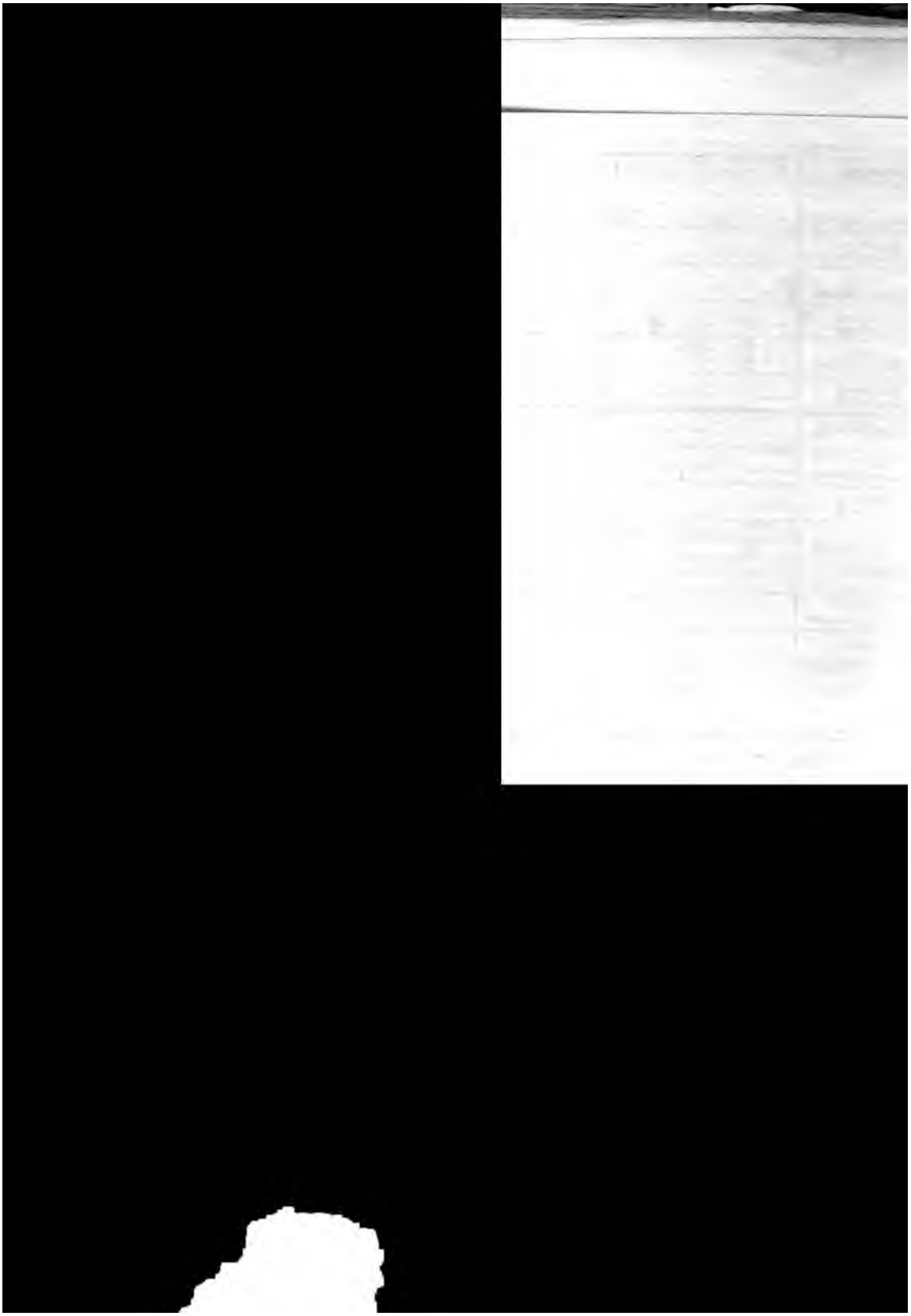
[2] In five instances the included angle has not been ascertained with suffic certainty to place the results in this table.

Table CVIII.

[T]RSE[T]

Districts.	Rocks.	0-10°													80-90°								
		Lodes heaved to the right hand.				*Lodes heaved* to the left hand.				*Lodes heaveles heaved* to the right ha left hand.					*Lodes heaved* to the right hand.				*Lodes heaved* to the left hand.				
		G.A.*		S.A.		G.A.		S.A.		.A.		A.		S.A.	G.A.		S.A.		G.A.		S.A.		
		Number of instances.	Average distance. Feet.	Number of instances.	Average distance. Feet.	Number of instances.	Average distance. Feet.	Number of instances.	Average distance.	Average distance. Feet.	Number of	Average distance. Feet.	Number of instances.	Average distance. Feet.	Intersected, but not *heaved*.	Number of instances.	Average distance. Feet.	Number of instances.	Average distance. Feet.	Number of instances.	Average distance. Feet.	Number of instances.	Average distance. Feet.	Intersected, but not *heaved*.
Saint Just	Granite.	..	..	..	..	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	1
	Slate ..	..	..	..	..	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Saint Ives	Granite†	..	..	..	..	..	..	..	.	..	..	1	24·0	..	..	..	2	2·5	..	..	..	..	1
	Slate ..	..	..	..	..	..	..	..	.	..	..	..	..	..	2	54·0	..	..	1	2.0	..	..	..
Marazion	Slate ..	..	..	..	..	..	..	..	.	..	..	..	..	..	3	24·0	..	..	..	..	..	..	..
Gwinear, &c.	Slate ..	..	..	..	..	..	..	..	.	6·0	5·6	..	..	..	4	4·2	1	2·0	3	2·0	1	1·0	5
Helston	Granite.	..	..	..	..	..	..	..	.	66·0	..	..	..	..	2	2·0	..	..	..	..	..	..	..
	Slate ..	..	..	..	..	..	..	..	.	..	..	4	15·5	3	..	..	..	..	..	..	1	4·0	..
Camborne, &c. .	Granite†	..	..	..	..	..	..	..	.	..	3·0	..	..	1	2	4·5	..	..	..	..	..	..	..
	Slate ..	..	..	..	..	..	..	..	.	..	..	..	..	2	2	2·0	..	..	..	..	..	..	..
Redruth, &c....	Granite.	..	..	..	..	..	..	..	.	..	..	..	..	..	2	72·0	..	..	1	3·0	..	..	2
	Slate† ..	..	..	..	..	..	..	..	.	59·0	33·0	1	14·0	2	16	11·3	..	..	3	14·0	1	2·0	5
Saint Agnes	Slate ..	..	..	..	..	..	..	..	.	..	1·0	..	..	..	1	9·0	..	..	1	48·0	..	..	3
Saint Austell...	Granite.	..	..	..	..	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Slate† ..	..	..	..	..	..	..	..	.	..	..	..	..	..	2	6·0	..	..	1	11.0	..	..	2
Tavistock, &c. ..	Granite.	..	..	..	..	..	..	..	.	..	..	..	..	..	1	3·5	..	..	..	..	..	..	..
	Slate ..	..	..	..	..	..	..	..	.	100·0	..	..	..	2	1	66·0	..	..	3	11·7	1	38·0	..
Number of examples, and mean distances of the *heaves*	Granite..	..	..	..	..	..	..	..	.	66·0	3·0	1	24·0	1	7	22·9	2	2·5	1	3·0	..	..	4
	Slate	..	..	..	..	..	..	..	.	56·0	7·9	5	15·2	9	31	15·1	1	2·0	12	12·0	4	11·2	16

† The direction of the *Western Trawn* in *Wheal Union* is unseen : i the side c
thereforey the *flucan*, are omitted ; they are, however, all towards the right.



throughout the districts here examined; and I now proceed to give a brief summary of its results:—

Angle included.	*Proportion not heaved.*	*Proportion heaved.*	*Av. dist. of heave.*
0°—10°			
10°—20°	0·4 ℔ cent.	0·4 ℔ cent.	6·0 feet.
20°—30°	0·8 „	3·1 „	15·3 „
30°—40°	0·8 „	3·1 „	24·2 „
40°—50°	0·4 „	6·7 „	32·4 „
50°—60°	2·6 „	5·8 „	19·4 „
60°—70°	4·8 „	11·9 „	12·4 „
70°—80°	4·3 „	20·7 „	15·9 „
80°—90°	8·7 „	25·5 „	14·3 „

The proportions respectively *heaved* towards the right and left hands, and greater and smaller angles, and the distances of the *heaves*, are shown in the following columns:—

	Right hand.		*Left hand.*	
Angle included.	*Proportion.*	*Av. dist. of heave.*	*Proportion.*	*Av. dist. of heave.*
0°—10°	—	—	—	—
10°—20°	0·4 ℔ cent.	6·0 feet.	—	—
20°—30°	2·6 „	16·1 „	0·4 ℔ cent.	11·0 feet.
30°—40°	1·8 „	36·2 „	1·3 „	8·3 „
40°—50°	4·1 „	42·8 „	2·6 „	16·7 „
50°—60°	2·6 „	12·6 „	3·0 „	25·3 „
60°—70°	6·7 „	17·6 „	5·3 „	5·8 „
70°—80°	14·1 „	18.1 „	6·7 „	11·1 „
80°—90°	18·1 „	15·5 „	7·5 „	11·3 „

	Greater angle.		*Smaller angle.*	
Angle included.	*Proportion.*	*Av. dist. of heave.*	*Proportion.*	*Av. dist. of heave.*
0°—10°	—	—	—	—
10°—20°	0·4 ℔ cent.	6·0 feet.	—	—
20°—30°	2·6 „	17·2 „	0·4 ℔ cent.	4·5 feet.
30°—40°	2·6 „	27·3 „	0·4 „	6·0 „
40°—50°	4·9 „	35·5 „	1·8 „	24·0 „
50°—60°	5·3 „	20·5 „	0·4 „	6·0 „
60°—70°	11·0 „	13·1 „	0·8 „	3·5 „
70°—80°	14·7 „	13·4 „	6·3 „	14·6 „
80°—90°	22·5 „	15·2 „	3·1 „	7·4 „

The foregoing columns prove that a very larg proportion of the intersections take place at gre angles:—from 70° to 90°. This seems to depe both on the general fact that, taking areas of lar extent, whatever may be the directions of the *lod* those of the *cross-veins* are often nearly at righ angles to them; and on the rectangularity usual existing between two series of the joints, or stru tural divisions of the rocks.[1]

That the extent of the *heaves* becomes smaller, t larger the angle included between the intersecti veins, has been long conjectured;[2] but the facts a now for the first time exhibited numerically.

Another general fact is, however, plainly disclos in the first part of the three tabular arrangement and it is apparent through the two others also:- namely, that there is an angle at which the exte of the *heaves* rises to a maximum, but that on eith side of it,—whether the included angle be great or less, the extent of the *heave* diminishes. Th maximum takes place when the angle is betwe 40° and 50°, and on either side of it there is (wi a single exception) a gradual diminution.

By the separation of the *heaves* as they occ towards the right or left hand, or to the greater smaller angle, the regularity of the progression either side of this angle of greatest displacement somewhat masked; the general fact is, howeve most clearly and decidedly established: its cause shall not attempt to assign.

[1] *Ante*, p. 170. [2] Mr. Hawkins, Corn. Geo. Trans., ii. p. 228.

Table CIX.

..	..	..	..	..	..
2	..	..	..	..	1
..	3†	..	..	..	..
..	1	..	2	..	1
..	..	..	..	..	..
1	7‡	1	3‡	..	2
..	..	..	..	..	..
..	..	..	..	..	..
..	3‖	1‖	..	..	2
1	1‖	1	1	..	1
..	2	..	..	..	1
3	4	..	..	..	1
1	..	..	2	..	1
..	..	..	..	..	..
..	..	..	..	..	..
..	..	..	..	..	..
..	..	..	1	..	..
8	21	3	9	0	10

sides, *travens*, or *cross-courses* dipping towards any point E. of a

7. *On the relations between the heaves of lodes and their dips, and those of the cross-veins by which they are intersected.*—

It has been seen that the extent of *heaves* is in some degree dependant on the angles included by the intersecting veins. If there be any general law respecting their *directions*, it may not unreasonably be expected to have reference also to the inclinations of the *lodes* or *cross-veins*, or of both.

One hundred and thirty-five *lodes* dip towards the north; and 75 of them are intersected by *cross-veins* dipping east, and 60 by others dipping west.

Ninety-eight *lodes* incline towards the south; and they are intersected by 55 *cross-veins* dipping eastward, and 43 dipping westward.

These numbers, 75, 60, 55, and 43, are respectively our points of comparison, and supply us with every possible combination of angles.

Lodes dipping north.

	Cross-veins dipping east.		*Cross-veins dipping west.*	
Intersections without *heaves*,	14·6 ℔ cent.	.....	40·0 ℔ cent.	
Lodes heaved to *right hand*—				
greater angle	42·6	,,	33·4	,,
,, *smaller angle*	9·5	,,	8·3	,,
Lodes heaved to *left hand*—				
greater angle	28·0	,,	8·3	,,
,, *smaller angle*	5·3	,,	10·0	,,

Lodes dipping south.

	Cross-veins dipping east.		*Cross-veins dipping west.*	
Intersections without *heaves*,	14·6 ℔ cent.	.....	23·2 ℔ cent.	
Lodes heaved to *right hand*—				
greater angle	50·9	,,	48·9	,,
,, *smaller angle*	5·5	,,	7·0	,,
Lodes heaved to *left hand*—				
greater angle	25·5	,,	20·9	,,
,, *smaller angle*	3·5	,,	—	,,

It may be of some use to consider the relations between the intersecting planes when one vein intersects another: for instance, when a *lode* inclining northward is intersected by a *cross-vein* dipping east.

The portion of rock (*Pl. I. Fig.* 1.) *a*, is thus included by the two upper surfaces *(hanging walls)* of the two veins; *b*, between their two lower faces *(foot walls)*; *c*, between the upper face of the *cross-vein* and the lower one of the *lode*; and *d*, between the lower plane of the *cross-vein* and the upper one of the *lode*.

Now, if the *lode* be *heaved* towards the right hand and greater angle, the obtuse-angled portions, *a* and *b*, will be respectively bounded by the upper faces of both the *lode* and *cross-vein*, and by their two lower faces: whilst the acute-angled portions, *c* and *d*, will be in like manner included,—the former, between the upper face of the *cross-vein* and the lower one of the *lode*; and the latter, between the upper face of the *lode* and the lower one of the *cross-vein*.

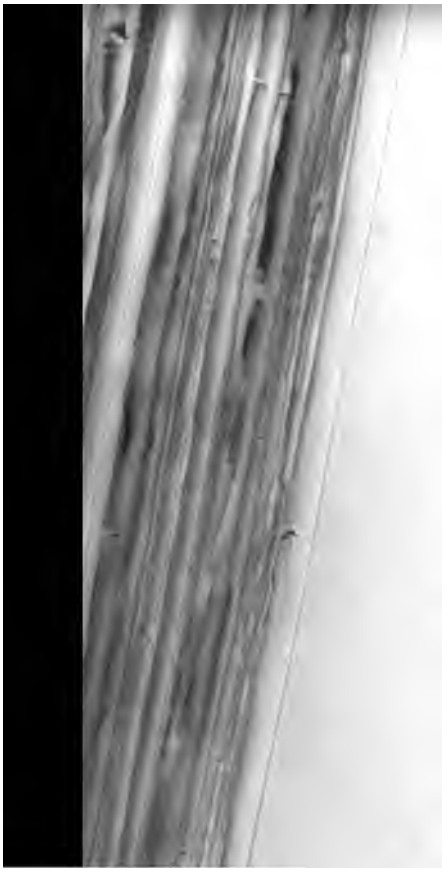
If the inclinations of the veins remain the same, but their directions be supposed to differ, so that the *heave* towards the right hand shall be towards the smaller, instead of the larger angle, as in the last instance, the only alteration will be that the portions which were acute-angled in the last case, will in this become obtuse.

Let us now suppose the directions and inclinations to remain the same as in the first case; but that the *heave* is towards the left hand and smaller angle. Here no other alteration will be effected; for *a* and

b will still be bounded by obtuse angles, and *c* and *d* by acute ones. Let the underlie of the *cross-vein* be now supposed to be westerly, that of the *lode* being still towards the north, and the *heave* still towards the right hand and greater angle. The acute-angled portions *c* and *d* will be the one included between the two upper, and the other between the two lower faces of the veins; whilst *a* will be contained between the upper plane of the *lode* and the lower one of the *cross-vein*, and *b* between the upper side of the *cross-vein* and the lower one of the *lode*.

The inclinations of the lines of actual contact between the veins will of course depend on the obliquity of their directions with regard to each other, and on the amount of their dips.

If, however, the directions of the *heaves* be dependent on, and in short necessary consequences of, the direction of the dip, either of the *lodes*, or of the *cross-veins*, or of both, such a dependance or law would become strikingly evident in such classifications of facts as the foregoing, and that in *Table* CIX.; where, if that hypothesis were true, the whole results would appear in certain columns. Nothing of the kind, however, occurs. There is not, indeed, an equal number of examples under every division; for the right-hand *heaves*, whatever the conditions, form 51·6 per cent. of the total number, whilst those towards the left hand are but 25·3 per cent. It is very remarkable, that whatever may be the dip of the *lodes*, their intersections by *cross-veins* dipping westward present an enormous preponderance of simple



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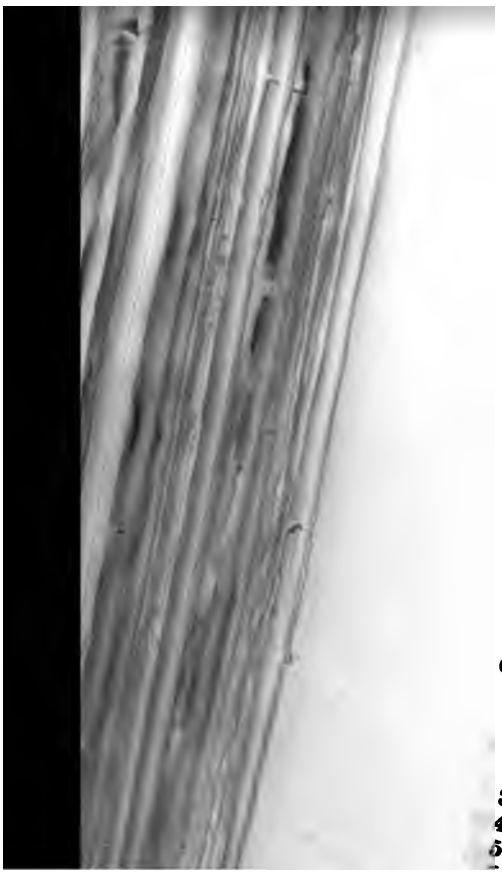
breadth of the *cross-veins:* which result we have seen to be in remarkable harmony with that obtained by comparing the distances of the *heaves* with the average dimensions of the *lodes* and *cross-veins* at the same levels.

Neither should it be lost sight of that, whilst *cross-veins* enlarge,[1] *lodes* dwindle,[2] as they descend; and that the increase of the one corresponds with the diminution of the other with an exactness so nearly perfect, that the difference is only about 4 per cent.; for they bear to each other the ratio of 3·96 to 3·80: a series of coincidences which can scarcely be thought fortuitous.

But a preceding part of this enquiry[3] has established the fact, that the extent of the *heaves* is in direct proportion to the width of the *lodes*, as well as to that of the *cross-veins:* whilst here it would, at first sight, appear that this part of our enquiry shows the extent of the *heaves* to be in direct proportion to the width of the *cross-veins*, and in an inverse one to that of the *lodes*. It must not be forgotten that a preceding investigation[4] has conclusively proved that the extent of the *heaves*, under similar circumstances, are in direct proportion to the width of the *lodes* as well as of the *cross-veins;* and this would lead us to expect that the diminution of energy in the one class of veins would be compensated by the increase of it in the other: and, therefore, that as their opposing influences so exactly counteract each other, any apparent differences in

[1] *Ante*, p. 243. [2] *Ante*, p. 276. [3] *Ante*, p. 300. [4] *Ante*, p. 300.



(*a.*) *Th*

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Depth.	*Heaves* to the
30 fms.	.....
40 ,,	.....
50 ,,	.....

At *Wheal Jewel* (in granite).

Heaves to the *left hand*, and *greater angle*—

Depth.	*Distance.*
20 fms.	72·0 feet.
50 ,,	54·0 ,,
60 ,,	48·0 ,,
70 ,,	36·0 ,,
80 ,,	36·0 ,,
90 ,,	30·0 ,,

At *Ting Tang*.

Heaves to the *right hand* and *greater angle*—

Depth.	*Rock.*	*Distance.*
90 fms.	Slate	21·0 feet.
120 ,,	,,	30·0 ,,
130 ,,	*Elvan*	8·0 ,,
140 ,,	Slate	Confused.

At *Duffield* (in slate).

Heaves to the *left hand* and *greater angle*—

Depth.	*Distance.*
18 fms.	2·0 feet.
68 ,,	18·0 ,,
88 ,,	9·0 ,,

At *Wheal Friendship* (in slate).

Heaves to the *left hand* and *smaller angle*—

Depth.	*Distance.*
26 fms.	60·0 feet.
40 ,,	42·0 ,,
60 ,,	18·0 ,,

Similar facts also occur in *Wheal Franco, Fowey Consols, Wheal Prudence, North Downs, Cardrew Downs, Wheal Falmouth, East Wheal Damsel, Tincroft, Cook's-kitchen, Herland, Wheal Union, Wheal Trenwith,* and in many other mines, both of tin and copper, and worked alike in granite and in slate.

(*a*–1.) The *cross-vein* which may be unifo
and compact at one point, in another sometim
subdivides into several veins. In some cases the
branches or minor-veins, though quite distinct, a
nearly in contact, the mass of rock between them bei
even of less thickness than the veins on either si
Nevertheless, the *lode* is often as distinctly traceab
and sometimes, indeed, is as rich in these minu
enclosed portions of the rock *(Country)* as in a
part of its uninterrupted course: and the *hea*
by each subdivision of the *cross-vein*, from one
these small included pieces of rock to another, is
well characterized as in the most considerable e
amples. This is remarkably the case in the *gre*
cross-course at *Wheal Peever (North Downs)*, whe
small *heaves* of this description are almost innum
able. The same remark is also applicable to t
great flucan at *Cardrew Downs*, and to others
Great Saint George, Redmoor, and *Wheal Frie*
ship.

(*a*–2.) In other cases the *cross-vein*, which is *sin*
at one level, becomes *branched at another*.[1] The
branches produce the same effects as if they h
been always separate and distinct. Indeed, the su
of all their effects on the *lodes* traversed, althou
sometimes less than that of the *cross-vein* united
one mass, is more frequently rather greater.

At *Stray Park* the *Boundary cross-course*,
162 fathoms deep, *heaves* the *north lode* 3 feet, a
the *south lode* 2 feet, both towards the right han

[1] Mr. Thomas, Report, p. 36.

at 178 fathoms deep, it simply intersects them both; and, at 188 fathoms deep, it divides into three veins, neither of which *heaves* either *lode*, although all of them intersect both.

At *Wheal Union*, the *trawn*, at 22 fathoms deep, *heaves* the *lode* 36 feet towards the right hand, and, at 30 fathoms deep, 25 feet in the same direction; but, at 43 fathoms deep, the *trawn* divides into three veins, of which one *heaves* the *lode* 24 feet, another 8 feet, and the third 1·5 foot,—but all the *heaves* are towards the right hand.

At *Carzise Consols*, a *flucan* intersects the *lode*. At 55 fathoms deep it does not *heave* it; but, at 65 and 75 fathoms deep, the *lode* is respectively *heaved* 9 and 5 feet towards the right hand. Again, at 85 fathoms deep, the *flucan* divides into three veins, each of which *heaves* the *lode* 4 feet in the same direction.

At *Wheal Vor*, the *eastern cross-course*, at 85 fathoms deep, *heaves* the *Main lode* one foot towards the left hand; but, at 140 fathoms deep, the *cross-course* divides into two veins: the *heaves* by both of which are also towards the left, and are as follow:—

Depth.	*Western branch.*	*Eastern branch.*
150 fms.	30·0 feet.	9·0 feet.
170 „	30·0 „	5·0 „
180 „		7·0 „

(*a*–3.) There are also *cross-veins*, for the most part composed of clay (*flucans*), of which there is no trace at or near the surface,[1] but which first appears at considerable depths.

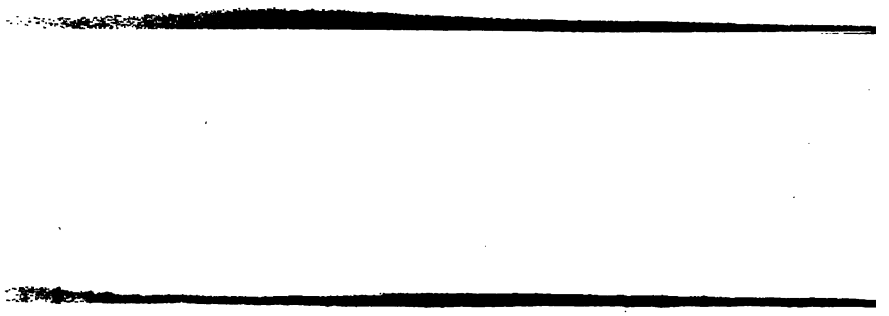
[1] This curious fact was first noticed by Mr. Thomas, Report, pp. 35–36.

At *Wheal Providence*, at 30 fathoms deep, the *Caunter lode* is *heaved* 6 feet towards the right hand by the *eastern flucan;* whilst, at 48 and 58 fathoms deep, the same *flucan heaves* the same *lode* 10 feet towards the left hand. In this case a remarkable alteration in the direction of the *flucan* occasions all the *heaves* to be towards the greater angle.

At the *United Mines, Tiddy's cross-course*, at 128 fathoms deep, *heaves* the *Old lode* 8 feet towards the right hand; and, at 148 fathoms deep, the same *cross-course heaves* the same *lode* 6 feet to the left hand. Here, too, the altered direction of the veins is the cause why both *heaves* are towards the greater angle.

The *Ore lode*, in *Wheal Robert*, is, at 12 fathoms deep, *heaved* 6 feet towards the left hand by the *cross-course;* whilst, at 24 fathoms deep, the *heave* of the same *lode* by the same *cross-course* is 18 feet towards the right;—in the former case towards the smaller, in the latter towards the greater angle: but instances of this kind are very rare, and can only be regarded as exceptions to the general rule. There are, nevertheless, cases in which *lodes heaved* at one level are simply intersected at another; and others where the maximum considerably exceeds double the mean extent of the *heave:* but these, too, are exceptions.

(*b.*) *The intersections of cross-veins by lodes* seem marked by the same irregularities as those of *lodes* by *cross-veins:* but, as *cross-veins* offer few inducements to mining enterprize, they are seldom much



worked; and, therefore, there are not many instances in which their intersections by *lodes* can be seen at different depths in the same mine.

At *Ting Tang*, *Roche's lode* intersects the *eastern flucan* at 90, 100, 110, and 120 fathoms deep, but there is no *heave* in either instance.

A similar fact is presented at *Trevaskus*, where the *lode* intersects the *eastern cross-course* at 33 and 51 fathoms deep, and, in both cases, without *heaving* it.

At *Wheal Trannack*, the *lode* intersects the *cross-course* at 34, 64, and 70 fathoms deep. In the first case the *cross-course* is *heaved* 2 feet, and in the last 9 feet, both towards the left hand, but, in the intermediate one, the intersection is not attended by a *heave*.

(*c.*) *The intersection of lodes by each other* present variations similar to those of their *heaves* by *cross-veins*, and of the *heaves* of *cross-veins* by *lodes*. Thus, at *East Wheal Crofty*, the *Longclose main lode*, at 30 and 46 fathoms deep, intersects the *Caunter lode* without *heqving* it; whilst, at 54 and 65 fathoms deep, the latter is respectively *heaved* 21 feet and 33 feet, and, in both cases, towards the right hand. In the same mine *Trevenson* and *Reeve's lodes* cross each other, but everywhere near their intersections they both split into strings.

At *North Roskear*, the *south lode* and *Wheal Crofty Caunter lode*, at 46 fathoms deep, run together in the direction of the former for 42 feet; but, at 12, 56, and 66 fathoms deep, they merely intersect.

At *Wheal Speed, Good Fortune lode heaves* the *Caunter lode* at 48 and 66 fathoms deep;—in the former 5 and in the latter 6 feet, and, in both cases, towards the right hand.

Similar facts occur at *Dolcoath*, the *Morvah and Zennor Mines*, and in several others.

10. *On the intersections of the same vein by several others.*—

(*a.*) *The intersection of one lode by several cross-veins* is not uncommon; but the results of such intersections bear little or no relation to each other. This might, indeed, have been anticipated: for, as the directions, dips, and other conditions, are subject to such frequent variations, each case will, for the most part, present a different combination or arrangement of these elements. I shall here restrict myself to the consideration of the results observed on the same horizontal plane; and examine those which occur at different levels in a subsequent chapter.[1]

At *Saint Ives Consols*, at 75 fathoms deep, the *Standard lode* is *heaved* 39 feet to the left hand (G.A.) by the *western trawn;* and its three veins, on a mean, 12·3 feet towards the right hand (G.A.) by the *middle trawn.*

In *Herland*, at 60 fathoms deep, the *Fancy Caunter lode* is *heaved* 21 feet towards the right hand (G.A.) by the *western flucan*, and 6 feet, in the same direction (G. A.), by *Bull's cross-course.* At 75 fathoms deep, *Manor lode* is *heaved* 1·5 foot towards

[1] On the appearances presented by the opposite sides of *cross-veins.*

the left hand (G.A.) by *Williams's flucan,* whilst the *Halfpenny flucan* merely divides it. At 132 fathoms deep, the same *lode* is *heaved* 1 foot towards the left hand (G.A.) by *Williams's flucan,* and 12 feet towards the right (G. A.) by the *Silver cross-course.* At 152 fathoms deep, this *lode* is also *heaved* 1 foot towards the right hand (G. A.) by the *Silver cross-course,* 12 feet in the same direction (G.A.) by the *Manor cross-course,* and 0·5 foot, also towards the right (G. A.), by the *Halfpenny flucan. Convocation lode,* at 75 fathoms deep, is *heaved* 1 foot towards the right hand (G. A.) by *Williams's flucan,* and 2·5 feet, in the same direction (S. A.), by the *Silver cross-course.*

At *Duffield,* the *South lode,* at 18 fathoms deep, is divided by the *eastern cross-course,* and, by the *flucan,* it is *heaved* towards the left hand (G. A.) 2 feet. At 88 fathoms deep, the same *lode* is *heaved* 9 feet towards the left hand by the *flucan,* and 4 feet towards the right (G. A.) by the *little flucan.*

At 74 fathoms deep, in *Binner Downs,* the *north lode* is intersected both by the *cross-course* and the *flucan,* but is not *heaved* by either.

At *Carnine,* the *lode,* at 55 fathoms deep, without any *heave,* is intersected by both the *flucan* and the *eastern flucan;* whilst, at 75 fathoms deep, it is *heaved* 5 feet by the *flucan,* and 4 feet by the *eastern flucan,* and, in both cases, towards the right hand (G. A.).

Wheal Sozan lode, in *Wheal Vor,* is, at 40 fathoms deep, *heaved* 54 feet to the right hand by *Woolf's*

cross-course, and 24 feet towards the left by the *eastern cross-course*; whilst, at 60 fathoms deep, it is *heaved* 42 feet by the former, and 27 feet by the latter. The *heaves* are, in every case, towards the smaller angle.

At *Polladras Downs*, at 43 fathoms deep, *Bissa lode* is merely intersected by the *cross-course*, whilst it is *heaved* 84 feet towards the right hand (G. A.) by the *flucan*. At the same level, *Pressure south lode* is simply traversed by the *cross-course*, whilst one vein of the *flucan heaves* it 24 feet, and another 18 feet, both towards the right hand (S. A.). At 103 fathoms deep, the *Engine lode* is merely divided by the *cross-course*, but the *flucan heaves* it 24 feet, and the *eastern flucan* 6 feet, both of them towards the right hand (S. A.).

At 162 fathoms deep, in *Stray Park*, the *north lode* is *heaved* 5 feet towards the left hand (G. A.) by the *Machine cross-course*, and 3 feet to the right (G. A.) by the *Boundary cross-course*. At the same depth, the *south lode* is *heaved* 3 feet towards the left (G. A.) by the former, and 2 feet to the right (G. A.) by the latter of these *cross-courses*.

At *Wheal Jewel*, the *lode*, at 20 fathoms deep, is *heaved* 12 feet towards the left hand (G. A.) by *Rodd's flucan*, 72 feet, in the same direction (G. A.), by *John's flucan*, 2·5 feet, towards the same hand (G. A.), by the *little flucan*, whilst the *Stony cross-course* simply intersects it.

The *lode*, at 50 fathoms deep, in *Wheal Franco*, is *heaved* 66 feet towards the right hand (R.A.) by

the *cross-course*, and 120 feet, in the same direction (G. A.), by the *flucan*.

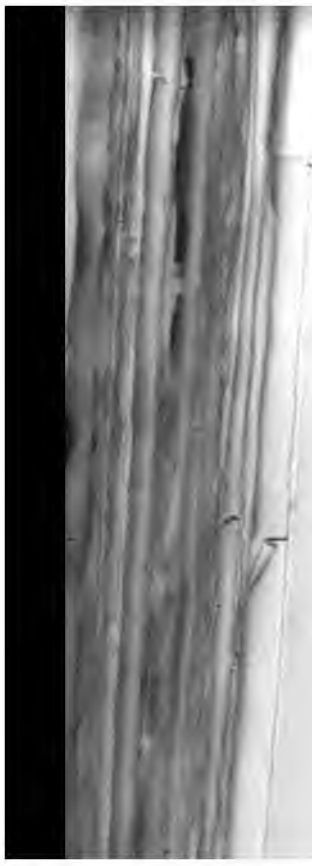
The preceding tables[1] contain full details respecting 55 *lodes*, each of which is traversed by TWO *cross-veins*. Of these 110 intersections, 20, or 18·1 per cent., are unaccompanied by *heaves;* 66, or 60·0 per cent., are *heaved* towards the right hand; and 24, or 21·9 per cent., towards the left:—74, or 67·3 per cent., towards the greater, and 16, or 14·6 per cent., towards the smaller angle. Of the 90 *heaves*, 48 (which are of 24 *lodes* by *heaves* two *cross-veins* each) are towards the same hand, whilst, in 42 instances, (21 *lodes* each *heaved* by two *cross-veins,*) the *heaves* of the same *lode* by two different *cross-veins* are towards *opposite* hands.

There are 9 examples of *lodes* each traversed by THREE *cross-veins*. Of these 27 intersections, 5, or 18·5 per cent., are unattended by *heaves;* 10, or 37·0 per cent., occasion right-hand *heaves;* and 12, or 44·5 per cent., are left-hand *heaves:*—20, or 74·0 per cent., are *heaved* towards the greater, and 2, or 7·5 per cent., towards the smaller angle.

Two *lodes* are intersected by FOUR *cross-veins* each. Of the intersections, 2, or 25·0 per cent., are unaccompanied by *heaves*, and, in the remaining 6, or 75·0 per cent., the *heaves* are all towards the left hand, and also, all to the greater angle.

It must not be forgotten that though in the Marazion, Gwinear, Helston, Camborne, Redruth, Saint Agnes, Saint Austell, and Tavistock districts the

[1] *Tables* I.–XCVIII.



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the *Old Tincrof*

(*c.*) *The heav*
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several others.—

(*a.*) *The interse*
cross-vein are very
ter, our enquiries
to intersections w

At 25 fathoms
Reeth guide heave
White's lode 3 fe
(G. A.).

The *trawn*, at
north and south b
(G. A.):—at 25 fat
feet, and the *south*

at 45 fathoms deep, the one 84 feet, and the other 69 feet.

In *Herland*, at 60 fathoms deep, *Bull's cross-course heaves Pleasure lode* (S. A.) and the *Fancy Caunter lode* (G. A.) both 6 feet towards the right hand. At 75 fathoms deep, *Williams's flucan heaves Pleasure lode* 2 feet towards the right hand (S. A.), and *Convocation lode* 2·5 feet in the same direction (G. A.); whilst *Manor lode*, which lies between the other two, is *heaved* 1·5 foot to the left hand (G.A.). At 97 fathoms deep, *Wheal Bailey western cross-course heaves Manor lode* (G. A.) 2 feet, and *Wheal Bailey lode* (S.A.) 0·5 foot, both towards the left hand.

At 18 fathoms deep, in *Duffield*, the *eastern cross-course heaves* the *Little north lode* 9 feet towards the left hand (G. A.), whilst it simply intersects the *south lode*.

At *Polladras Downs*, at 33 fathoms deep, the *flucan heaves Pressure north lode* 24 feet, and *Pressure south lode* 42 feet, both towards the right hand (S. A.); and, at 83 fathoms deep, it *heaves* the former *lode* 72 feet and the latter 42 feet, in the same direction; and the same *flucan*, at 43 fathoms deep, divides both *Bissa* and *Pressure south lodes* but *heaves* neither of them. At 83 fathoms deep, the *eastern flucan heaves* the *Engine lode* 3 feet towards the right hand (S. A.), whilst it simply traverses *Bissa lode*.

Analogous facts occur at *Stray Park*, *Cook's-kitchen*, *Tincroft*, *Cairn Brea Mines*, *Ting Tang*, the *Consolidated* and *United Mines*, *East Wheal*

Damsel, Wheal Jewel, Cardrew Downs, North Downs, Wheal Prudence, Polberrow, Dowgas, Fowey Consols, Beam, and *Redmoor,* but, as the details will be found in the previous tables,[1] it is unnecessary to recapitulate them here.

Of the same *cross-veins* intersecting two or more *lodes,* 114 instances have been described in the foregoing pages. Of these, 40 *cross-veins* intersect *two lodes* each, 4 *cross-veins* intersect *three lodes* each, 2 *cross-veins* intersect *four lodes* each, and 1 *cross-vein* intersects no less than *fourteen* different *lodes* and veins.

Of the 80 *lodes* which are traversed by the 40 *cross-veins,* 56 dip towards the north, and 24 towards the south: 46 *lodes,* or 57·5 per cent., are *heaved* towards the right hand, and 11, or 13·7 per cent., towards the left; and, in 23 cases, or 28·8 per cent., there are simple intersections only: 48, or 60·0 per cent., are *heaved* to the greater, and 9, or 11·2 per cent., to the smaller angle.

Of 18 *lodes* traversed by 9 *cross-veins,* the results (22·5 per cent.) are simple intersections: 8 *cross-veins* each merely intersects one of the *lodes,* and *heaves* the other of them towards the right hand (10·0 per cent.); 1 *cross-vein* intersects one *lode,* whilst it *heaves* the other towards the left hand (2·5 per cent.): whilst, of 26 *cross-veins,* each *heaves* its own two *lodes* in the same direction (65·0 per cent.). Of these 26 *cross-veins,* 21 *heave* both the *lodes* they

[1] *Tables* I.–XCVIII.

traverse towards the right hand, and the remaining 5 of them *heave* both the *lodes* they intersect towards the left hand.

Of the 4 *cross-veins* which intersect three *lodes* each, one simply traverses all three; two others *heave* to the right hand (G. A.) all the six *lodes* which they intersect; and the fourth *heaves* two of the *lodes* towards the right hand, and one towards the left. Thus, 8 *lodes*, or 66·7 per cent., are *heaved* towards the greater angle; 1, or 8·3 per cent., towards the smaller; and 3, or 25·0 per cent., suffer simple intersections:—8, or 66·7 per cent., are also *heaved* to the right; and 1, or 8·3 per cent., towards the left hand.

Therefore the cases of simple intersections are 3, or 25·0 per cent.: only 1 *lode*, or 8·3 per cent., is *heaved* (left hand) in a contrary direction to the two others *heaved* by the same *cross-vein;* whilst the remaining 8, or 66·7 per cent., are all *heaved* (right hand) in the same direction. Of these 12 *lodes*, 8 dip towards the north, and 4 towards the south.

There are 2 *cross-veins* which *heave* four *lodes* each, and all of the *heaves* are in the same direction, towards the greater angle and right hand: 6 of them dip to the north and 2 to the south.

Of the 14 *lodes heaved* by the same *cross-vein*, 7 are *heaved* towards the right hand, and 7 to the left; and, owing to a change in the direction of the *cross-vein*, all of them are *heaved* towards the greater angle: 3 of them dip towards the north, and 11 towards the south.

Of the whole 114 *lodes*, thus intersected, 73 dip towards the north, and 41 to the south.

21, or 18·4 ℔ cent., of them are unattended by *heaves;* in—
10, ,, 8·8 ,, one *lode* is simply intersected, whilst the other is *heaved;* and in—
80, ,, 70·2 ,, both *lodes* are *heaved* in the same direction: or, rather, the 2, 3, or 4 *lodes heaved* by the same *cross-vein* are all *heaved* towards the same hand.
One *cross-vein*, which *heaves* 3 *lodes*, *heaves*—
2, ,, 1·7 ,, towards the same hand; and—
1, ,, 0·9 ,, in the opposite direction.

Seeing, therefore, that more than 97 per cent. of the whole number of *lodes* thus traversed are either *heaved* in the same direction, or are simply intersected,—whilst less than 3·0 per cent. are *heaved* in opposite directions, it may be calculated, generally, *that the heaves of all lodes, by the same cross-vein, are in the same direction.* Here, then, we have a plain and safe rule, and one (with the few exceptions already noticed[1]) capable of universal application.

(*b.*) *Of several cross-veins intersected by the same lode, at the same level,*[2] I have met with no example.

(*c.*) *The same lode intersects several others* in very few instances.

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[1] It has been already seen that, at *Herland*, a *heave*, towards the left hand, occurs between two towards the right, by the same *cross-vein*. *Ante*, p. 321.

[2] At *Trevaskus*, at 21 fathoms deep, the *lode*, which dips north, intersects the *western cross-course* which dips east; and, at 33, and also at 51 fathoms deep, it traverses the *eastern cross-course* which dips west:—but, in all cases, it merely divides them.

At *Wheal Budnick*, the *lead lode*, at 34 fathoms deep, intersects *Wheal Golden cross-course* dipping south-west, and, at 64 fathoms deep, another *cross-course* dipping north-east, and it *heaves* both of them towards the left hand.

Any inference which can be drawn from these facts favours the view already given.

At 16 fathoms deep, in *Wheal Bellon, Wheal Owl lode heaves Cock's lode* 4 feet towards the left hand (S. A.), and *Pollan-narrow lode* 144 feet to the right (G. A.).

At *Botallack*, the *Crowns, Wheal Hazard,* and *Codna Reeth lodes* intersect; — at *Dolcoath,* the *Caunter, Harriette's,* and the *Main lodes,* fall in contact;—and, at *North Roskear,* the *Caunter, Engine,* and *south lodes,* also meet each other: but the results of all their intersections are obscure.

The general inference, however, seems to be, that the rule which so strictly applies to the intersections of several *lodes* by the same *cross-vein,* cannot, with any certainty, be applied to the intersections of *lodes* by each other.

12. *A vein which in one spot intersects another, is itself sometimes intersected by a vein similar to that which it had traversed elsewhere.*—

(*a.*) *Cross-veins which in some spots intersect lodes, are, in other places, themselves intersected by lodes similar to those which they had traversed.*—

At 18 fathoms deep, in *Duffield,* the *eastern cross-course heaves* the *north lode* and intersects the *south lode,* but is itself intersected by *Holman's lode,* which is situated between the other two. The composition of the three *lodes* is almost exactly similar.

At 70 fathoms deep, in *Dolcoath, Wheal Bryant cross-course heaves* two veins (one of them being in slate on the east of the *cross-course,* and in *elvan* on the west; whilst the *elvan-course,* itself a vein in the slate, is not *heaved),* and the *cross-course* is itself *heaved* by *Entral north lode.*

At 26 fathoms deep, in *Tincroft*, the *eastern cross-course* is *heaved* by *Old Tincroft lode:* the *cross-course* then *heaves Highburrow* and *Martin's lodes;* is itself again *heaved* by *Dunkin's lode;* and, lastly, it *heaves* the *south lode.* The *cross-course* thus *heaves* three *lodes*, and is itself *heaved* by two other *lodes;* and the *heaves* of two of the *lodes* are interposed between the two *heaves* of the *cross-course.* The same *cross-course* also intersects an *elvan-course* and several granite veins without *heaving* any of them, whilst it *heaves* certain other similar veins of granite.

(*b.*) *Lodes, which at some spots intersect others, are, in other places, themselves intersected by lodes similar to those which they had elsewhere traversed.*—

At 16 fathoms deep, in *Wheal Bellon, Wheal Owl lode heaves Cock's* and *Pollan-narrow lodes,* but is itself *heaved* by *Wheal Venton lode.*

At 110 fathoms deep, in *Fowey Consols, Bone's lode heaves Crosspark lode,* but is itself *heaved* by *Jeffery's lode.*

(*a*-1.) *Cross-veins, at some levels, intersect lodes, by which, at others, they are themselves intersected.*—

At the *Morvah and Zennor Mines,* the *lode,* at 28 fathoms deep, simply intersects the *north course;* at 40 fathoms deep, the *north course heaves* the *lode;* at 50 fathoms deep, the *lode* once more meets, and at the same time *heaves* the *north course;* whilst, at 60 fathoms deep, the *north course* again *heaves* the *lode.* Here, then, we have, within a short distance, the unparalled example of two veins *each twice* intersecting the other.

At 112 fathoms deep, in *Great Work, Wheal Breage lode* is *heaved* by the *cross-course;* at 122 fathoms, the *cross-course* is itself divided by the *lode;* and, at 132 fathoms deep, the *lode* is divided by the *cross-course,* but here it is not *heaved.*

In *Tincroft,* at 26 fathoms deep, the *eastern cross-course* is *heaved* by *Dunkin's lode;* but, at 84 fathoms deep, the *cross-course heaves* the *lode.*[1]

(*b*-1.) *Lodes which at certain depths intersect others, are, at other levels, themselves intersected by the same lodes.*—

In *Dolcoath,* at 56 and 76 fathoms deep, the *Caunter lode heaves Harriette's lode;* but, at 96 and 116 fathoms deep, *Harriette's lode heaves* the *Caunter.*[2]

At *Polgooth, Reskilling Great elvan heaves Saint Martin's lode* 42 feet, and *Screed's lode* 6 feet; whilst *Saint Martin's lode* simply intersects the *Little elvan.* This is the only example of *elvans heaving lodes* with which I am acquainted.[3]

In order, however, that a *heave* should take place, it does not seem absolutely necessary that the *lode* should be traversed, either by another *lode,* a *cross-vein,* or, indeed, a vein of any other sort, or even by a joint of the rock; for, at *Balnoon,*[4] the *lodes* are frequently cut off and *heaved* by the joints of the

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[1] It is a remarkable fact that the different branches of *cross-veins,* when separate, invariably *heave* the *lodes* in the same direction as when united, whether at the same or at different levels, as at *Wheal Vor* and *Wheal Peever.*

[2] This interesting fact was first published by Mr. R. W. Fox, from Captain Petherick's description. Phil. Trans. (1830), pp. 404–414, Fig. 27.

[3] Mr. Hawkins, Cornwall Geo. Trans., i. p. 151. Pl. vi. [4] *Ante.,* p. 25.

rock,[1] and often, too, when these are wanting. Of the latter kind there is also an instance at *Dowgas*, where four *lodes* abruptly terminate alike without the intervention of either joint or vein, and are again found to commence with similar abruptness, nearly at right-angles, and at a distance of about 4 fathoms.

Other similar cases may be cited, but these are very rare in comparison with the *heaves* which are occasioned by veins, and are, therefore, merely exceptions to the general rule. They are, nevertheless, objects of the greatest interest; since they not only encourage the miner in his search for the continuation of *lodes*, which otherwise he might have thought had come to an end, but also supply additional materials for speculation on the origin and causes of the remarkable characters common to *lodes*, in most, if not in all, mining districts.

Having described the horizontal interferences of *lodes* with each other, and with *cross-veins*, in consequence of their directions, we come next to—

II. VERTICAL INTERSECTIONS,

produced by the different inclinations of veins which have nearly parallel directions.

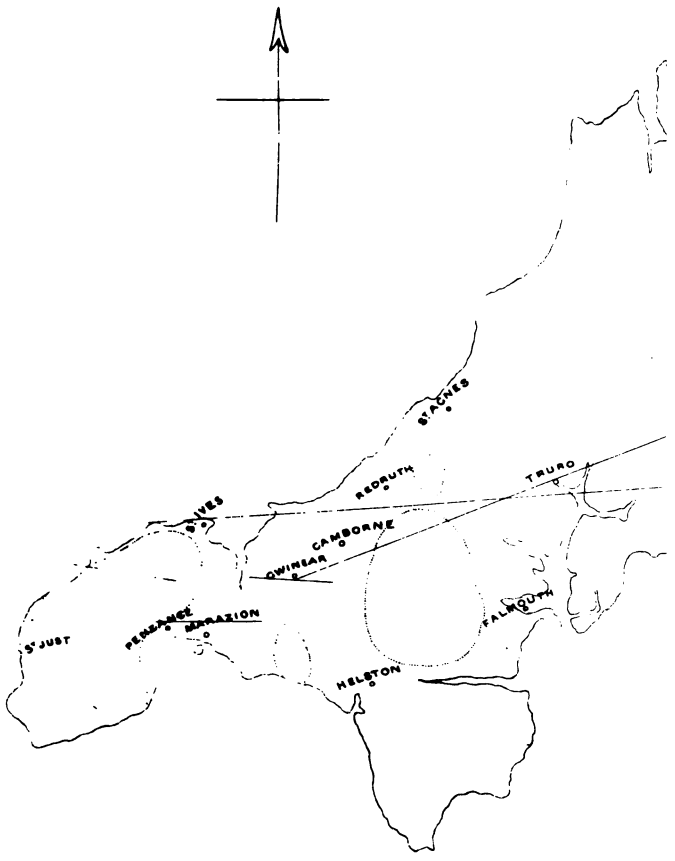
The results of these intersections are,—that one vein either simply traverses, or dislocates or displaces the other. In the latter case the severed

[1] Mr. Hawkins, Cornwall Geo. Trans., ii. p. 241.

Fig 5.

CORNWALL

Showing the mean direction of the Lodes in the different Mining districts.



R. T. Hall del.

is found by following the line of the tra-
ein, either *upwards*, as from *a* to *b*, *Pl. XI.*
r *downwards*, as from *y to z*, *Pl. XI. Fig.* 8.
rior portion of the former is found on the
the greater angle, and in this the *lode* is
ıve *leaped* or to be *thrown* upwards :—in the
e deeper portion of the *lode* is found on the
he smaller angle, and the *lode* is, in mining
, said to have *leaped* or to be *thrown* down

th the single exception of *Wheal Vyvyan*,[1]
lides[2] occur in the slate series,[3] and none of
ceed a foot in breadth,[3]—and as in no in-
ıas the same vein been seen to intersect
more than once, or to interfere with more
other vein on the line of its dip, our objects
ination will be much fewer than in the cases
ontal intersections.

enquiry, therefore, seems confined to the
ation of (1) the nature of the intersecting
l (2) that of the vein intersected; and (3) of
ıence the angle, at their intersection, may
he direction or distance of the *leap* or *throw*.

[1] *Ante*, p. 73.

nte, p. 282) are veins of clay in direction nearly parallel to the
ıich, for the most part, traverse them: but the same term is often
nate the result of the intersection, as well as to describe the inter-
In the Saint Agnes district, however, these traversing veins often
ıy brown iron ore, and are called "*gossans*;" and here the dis-
designated a *leap*,—a provincial term used by Mr. Pryce (Mineral.
06), which seems to express the effect produced as well as any
seen. Mr. Carne (Corn. Geo. Trans., ii. p. 119) has introduced
ow as a synonym. The expressions *throw* and *leap* are therefore
and *slide* is often used, by miners, in the same sense.

[3] *Ante*, p 282.

These considerations are equally applicable to the interference of *lodes* with *slides* and with each other.

1. *On the relations between the mineral composition of the traversing veins and the results of the intersections.*—

(*a.*) *The intersections of lodes by slides.*—Seven examples of the intersections of *lodes* by *slides* have occurred to me in the course of this enquiry; and in 3 of them the *slide* simply traverses the *lode*, in 2, the *lode leaps* upwards towards the smaller angle, and in 2, downwards and towards the larger angle.

(*b.*) *The intersections of some lodes by others on the lines of their inclinations.*—I have seen 9 *lodes* intersected in this manner by other *lodes*. In one instance 1 *lode* simply traverses the other, and, in the remaining 8, the *leaps* are upwards:—3 are towards the larger, and 5 towards the smaller [illegible]

2. *On the relations between the mineral comp[illegible] of the veins vertically intersected, and the res[illegible] their intersections.*—

(*a.*) *The intersections of lodes yielding diffe[illegible] ores by slides.*—Of the 7 *lodes* intersected by *slid[illegible]* 2 are tin *lodes* and 5 are copper *lodes:* in the forme[illegible] the *leap* of both is upwards and towards the smalle[illegible] angle; whilst, in the latter, 2 *leap* downwards towards the greater angle, and the other 3 are simply intersected.

(*b.*) *The vertical intersections of lodes by each other.*—Of the 9 intersections of *lodes* by each other, 4 are of copper *lodes* by each other, 3 are of tin *lodes* by *(gossan)* copper *lodes*, and 2 are of tin *lodes* by each other.

Table CXII.

Angles included between the veins, on the lines of their horizontal bearings.	0-10°				10-20°				20-30°				30-40°				40-100°				100-170°				170-180°				Totals and Means.	
	Lodes thrown up.		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*			
	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.		
0–10° ..	Number of instances.																												1	
	Average distance. Feet.																												9·0	
10–20° ..	Number of instances.																													
	Average distance. Feet.																													
20–30° ..	Number of instances.																												2	
	Average distance. Feet.																												4·5	
30–40° ..	Number of instances.																												1	
	Average distance. Feet.																												114·0	
40–50° ..	Number of instances.																													
	Average distance. Feet.																													
50–60° ..	Number of instances.																													
	Average distance. Feet.																													
60–70° ..	Number of instances.																													
	Average distance. Feet.																													
70–80° ..	Number of instances.																													
	Average distance. Feet.																													
80–90° ..	Number of instances.																													
	Average distance. Feet.																													
Totals & Means.	Number of instances.																												4	
	Average distance. Feet.																												32·7	

Table CXIII.

Angles included between the veins, on the lines of their horizontal bearings.		0–10°				10–20°				20–30°				160–170°				170–180°				Totals and Means.	
		Lodes thrown up.		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*		*Lodes thrown up.*		*Lodes thrown down.*			
		G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.	G.A.	S.A.		
0–10°	Number of instances.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	61°
	Average distance. Feet.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
10–20°	Number of instances.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
	Average distance. Feet.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
20–30°	Number of instances.	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..		
	Average distance. Feet.	2.*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2.	..		
160–170°	Number of instances.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
	Average distance. Feet.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
170–180°	Number of instances.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
	Average distance. Feet.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
Totals and Means.	Number of instances.	9	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	..		
	Average distance. Feet.	50·	..	150·	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	61·	..		

* Ad

Of the 2 tin *lodes* intersected by each other, both *leap* upwards and towards the greater angle; of the 3 tin *lodes* by *(gossan)* copper *lodes*, all *leap* upwards,—2 towards the smaller and 1 towards the larger angle; whilst, of the 4 copper *lodes* intersected by each other, 1 is simply intersected, and the other 3 *leap* upwards, and all towards the smaller angle.

At *South Wheal Towan*,[1] the *Slide lode* which occasions the *leap* is in two veins. These include between them a mass of rock *(Country)* in which there is a portion of the intersected *lode*,—in regular and conformable position as to dip, but wholly separated from both the other segments of the *lode*.

At that part of *Gwallon* where I saw the contact between the tin *lode* and the *slide*, the *slide* was simply intersected by the *lode*. I have been since informed[2] that in other parts of their course the *slide* intersects the *lode*.

At *Polgooth*, the *flucan* intersects the *Little elvan* and *Saint Martin's lode*, and, in both of them, occasions a *leap* of 114 feet upwards to the smaller angle. At *Wheal Unity Wood*, the *slide* intersects the *elvan-course*, but causes no *leap*; whilst, at its contact with the *flucan*, there is such a resemblance between their ingredients as to render the result indistinct.

The *lode*, at *Penwinnick*, although simply intersected, becomes somewhat deflected, and, on either

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[1] *Ante*, p. 178.

[2] Captain Williams informs me that this has occurred in a different part of the mine, explored since my visit. Mr. Carne also gives the same statement,—Corn. Geo. Trans., ii. p. 92.

side of the *slide*, partakes of its direction for some distance. This, we have already seen, is also a common case in horizontal intersections, as at *Wheal Cunning*, *Boscaswell Downs*, and *East Pool*.

There are several doubtful cases, as at *Cook's-kitchen* and *Tincroft*, which on that account I omit from this classification.

It seems almost superfluous to repeat here that *lodes* frequently coalesce, both horizontally and vertically.[1]

We possess only sixteen examples of vertical intersections: an insufficient number from which to draw any sure inferences. It is, however, not unworthy of remark, that of the *leaps* of *lodes* intersected by *slides*, all those of the tin *lodes* are upwards and towards the smaller angle, whilst all the copper *lodes* present either simple intersections, or *leaps* downwards towards the greater angle.

It is interesting to compare even this small number of vertical intersections with the horizontal intersections of *lodes* by *cross-veins*.

The intersections of *lodes* by *flucans* show a numerical preponderance of *heaves* towards the greater angle,[2] and, also, that the extent of the *heaves* is greater with tin than with copper *lodes*, which also holds true in the *leaps* occurring with vertical intersections; whilst the displacement (whether a *heave* caused by a *flucan*, or a *leap* occasioned by a *slide*) of copper *lodes* is more frequently towards the greater angle[3] than is the case with *lodes* yielding other ores.

[1] *Ante*, p. 176. [2] *Ante*, p. 291. [3] *Ante*, p. 287.

Again, the *heaves* of *lodes* by each other,[1] and by *cross-courses*,[2] exhibit a larger proportion of *heaves* towards the smaller angle than results from their *heaves* by *flucans*.[3] This law most remarkably prevails in their vertical intersections also; for the *leaps* towards the smaller angle are in much larger proportion than those towards the greater angle:—an excess which also holds good when the *leaps* caused by the intersections of *lodes* by each other are compared with those of *lodes* traversed by *slides*.

In fact, whether the intersection be horizontal or vertical, and produced either by another *lode* or by a *cross-course*, under any of these conditions it seems evident that the displacement, whether it be a *heave* or a *leap*, is far more commonly to the smaller angle when the traversing vein has a quartzose, than when it has a clayey, character: and, also, that of the harder descriptions of the *lodes*, such as the tin *lodes*,[4] a larger proportion is re-discovered towards the side of the smaller than of the larger angle

These circumstances rather indicate that the *direction* of the *heave* or *leap* may be affected by the mineral composition of the *intersected*, as we have already seen it is by that of the intersecting vein.[5]

These facts seem to hint that whilst the dimensions[6] of the veins, and the angles they include,[7] regulate the *distance* of the displacement, their

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[1] *Ante*, p. 289. [2] *Ante*, p. 292. [3] *Ante*, p. 291.

[4] Mr. Carne, Corn. Geo. Trans., ii. p. 87: Mr. R. W. Fox, Corn. Polytech. Soc. Report (1836), p. 121.

[5] *Ante*, p. 330. [6] *Ante*, pp. 297-8. [7] *Ante*, p. 301.

mineral characters, in some degree, influence its *direction.*

3. *On the influence which the angles included exercise on the results of vertical intersections of veins.*—

The following columns indicate the angles included in the sixteen examples before us, and also the results of the intersections:—

Angles.	*Number of instances.*	*Results.*
0°—10°	—	—
10°—20°	1	Intersection.
20°—30°	1	Up, 3 feet S.A.
30°—40°	—	—
40°—50°	5	2 intersections. 1 up, 12 feet G.A. 2 up, average 61 feet S.A.
50°—60°	1	Up, 240 feet S.A.
60°—70°	2	1 up, 18 ,, G.A. 1 up, 150 ,, S.A.
70°—80°	1	Intersection.
80°—90°	5	2 down, average 7 feet G.A. 1 up, ,, 15 ,, ,, 2 up, ,, 27 ,, S.A.

Some traces of the general fact previously indicated[1] by the horizontal intersections are apparent here also; for the maximum extent of the *leaps* seems to take place when the included angle is somewhere between 40 and 70 degrees; on either side of which the distances seem to diminish. An average from so small a number of instances is not worthy of much confidence if taken by itself: but, whatever consideration may be given to these facts, be it little or much, they, to that extent, support the general law already disclosed.[1]

[1] *Ante*, p. 301.

The appearances of the opposite *walls* of *lodes* having been already[1] discussed, I shall in this place consider

THE APPEARANCES AND RELATIVE POSITIONS OF THE ROCKS AND VEINS WHICH FORM THE OPPOSITE WALLS OF CROSS-VEINS.

It is frequently asserted, as a fact not admitting of dispute, that when one vein traverses another, the severing is newer than the severed vein; and, consequently, that the portions of the latter lying on opposite sides of the former were once united: but, if this be true, it necessarily follows that a perfect and exact coincidence will be found between the dimensions and configuration of these parts; and, also, that the portions of different veins divided by the same *cross-vein* will be found to preserve, on both sides of it, the same relative distances from each other, either at the same level when the fracture has produced a simple separation, or at different ones when one or both of the severed portions have undergone any motion, either at the time of fracture, or subsequently.

No part of our enquiry is more important than this. For if this coincidence can be established, we have only to ascertain the relative positions of the severed portions of any vein divided by another, and we have a guide to the respective situations of all

[1] *Ante*, p. 195.

other veins intersected by the same *cross-vein*:—at least, of all within moderate limits.

The *heave* of one *lode* by a *cross-vein* being known, we have in this coincidence a sure and infallible guide,—an unavoidable, necessary, and unerring law, which will at once indicate in what directions and at what distances all other *lodes heaved* by the same *cross-vein* may be re-discovered.

I need not enlarge on the value and importance of such a discovery; for by it the doubts and perplexities with which practical miners have been for ages beset, will be at once removed, and the fruitless cost so often incurred in trying to solve the question of their mutual dependence will for ever be avoided; since the re-discovery of a *lode heaved* by a *cross-vein*, instead of requiring experience and observation, will henceforward be merely a matter of simple computation.

But it is not by the examination of any *single heave*, or of any number of *heaves* taken each singly, that the truth or falsehood of this position can be established, or that we can make manifest the resemblance or dissimilarity of the divided portions of the same *lode*, or of the relative distances of different *lodes* on opposite sides of the same *cross-vein*. For if we assume that a motion has taken place to such an extent and in such direction as may be requisite, we may solve, at least within certain moderate limits, the problem of any *single heave*. The difficulty, however, lies in the mutual connexion of *several heaves*, for the motion which will reduce

one series of displacements to a tolerable continuity may be found to increase our difficulties respecting other *heaves* by the same *cross-vein.* It is, therefore, only by a comparison of several intersections by the same *cross-vein,* at the same and at different levels, that we can hope to arrive at truth or certainty. In making this comparison I shall confine myself to examples in which the identity of the veins is beyond dispute; and I now proceed to the details which I think will supply ample materials for the confirmation or rejection of this theory.

(*a.*) At *Wheal Bolton,* the *Middle lode* dips towards the south, and the *south lode* towards the north, yet the *cross-course heaves* both towards the right hand,—the former 18 feet, and the latter 12 feet: and beside being so *heaved,* both of them accompany the *cross-course* for several fathoms.

(*b.*) At *Stray Park,* the *north lode* dips towards the south, and the *south lode* towards the north, yet at certain levels both are *heaved* towards the right hand by the *Boundary cross-course,* and also towards the left hand by the *Machine cross-course;* at other levels, however, these *lodes* are simply intersected by the *cross-courses.*

At 146 fathoms deep, the *south lode* is 2 feet wide on the western side of the *Boundary cross-course,* but on its eastern side the lode is 6 feet in breadth: thus whilst the south *wall* of the *lode* seems merely intersected, the north one appears to be *heaved* 4 feet.

(*c.*) At *Cook's-kitchen, Dunkin's lode* dips to the south, and the *Middle Engine lode* towards the

north, but both are *heaved* to the right hand by the *Little cross-course*, which also intersects one *elvan-course* on the north, and another on the south of the *lodes*, but *heaves* neither of them.

(*d.*) At *North Roskear*, the *Caunter lode* dips southward, and both the *Engine* and *south lodes* towards the north, but the *cross-course* simply intersects the two last, whilst it *heaves* the first 8 feet towards the left hand.

(*e.*) At *Cardrew Downs*, the *south lode* dips to the north, and the *north lode* towards the south, and between them is an *elvan-course* dipping south-west, from which several veins strike off into the adjacent slate. The *lodes*, the *elvan-course*, and the veins of *elvan* are all traversed by the *Little flucan;* but whilst the *elvans* are simply intersected, both *lodes* are *heaved* towards the right hand,—the former 24 feet, and the latter 15 feet. In the same mine the *Great flucan* simply intersects the same *elvan-course* and its off-shoots, whilst it *heaves* the *south lode* 100 feet towards the right hand.

(*f.*) At *Wheal Unity Wood*, the *flucan* simply intersects the *elvan-course*, whilst it *heaves Pits-an-vollar lode* 21 feet, *Trefusis lode* 12 feet, and the *Little ore lode* from 30 to 36 feet, all towards the left hand. The *elvan* and all three *lodes* dip northwards.

(*g.*) At *Wheal Prudence*, the *elvan-course* and the *north lode* dip to the north, and the *south lode* towards the south. The *cross-course heaves* all of them towards the right hand, the *elvan* 30 feet, the *north*

lode 9 feet, and the *south lode* a distance varying from 18 to 30 feet at different levels.

(*h.*) At *Polberrow*, the *eastern cross-course heaves* the *Pye* and *North Seal Hole lodes* each 9 feet, and the *South House* and *Great Gossan lodes* each 12 feet: the first two dip towards the north, and the two last towards the south, and all of them at different angles,—nevertheless they are all *heaved* towards the right hand.

(*i.*) In the western part of the *Consolidated Mines* *Tiddy's cross-course* simply intersects an *elvan-course* which dips north-west, and also *Glover's branch* which dips towards the south, with a very variable inclination; but it *heaves Michell's lode*, which also dips southward, 3 feet towards the right hand; and *Paul's lode*, which dips towards the north, from 15 to 18 feet in the same direction. In the corresponding part of the *United Mines* (south of the *Consolidated)* the same *cross-course heaves* the *Old lode* 8 feet towards the right hand at one level, and 6 feet to the left at another: it also *heaves* the *Mundic lode*, which dips northward, 9 feet towards the right hand, and *Gellard's north* and *south lodes*, which have a southerly dip, each 6 feet towards the left.

(*j.*) The *western flucan*, in *East Wheal Damsel*, *heaves* both *lodes* 72 feet towards the right hand, although they dip in opposite directions; whilst *Stevens's flucan*, at different levels, *heaves* them to different distances, but always towards the left hand.

(*k.*) At *Wheal Union*, the *trawn*, at 43 fathoms deep, is in three veins, which, above and below that

level, are united into one; but, whether separate or united, at their intersections *Wheal Gwens lode* is always *heared* towards the right hand. Where the *trawn* is single at one level the *heave* is 36 feet, at the next 25 feet, and at the third, where it divides, one vein *heaves* the *lode* 1·5 foot, the second 8 feet, and the third 24 feet. The *western trawn heaves* the same *lode* 6 feet in the same direction.

(*l.*) At *Wheal Vor*, at 40 and 60 fathoms deep, the *Main lode* is *heaved*, respectively, 24 and 27 feet by the *eastern cross-course*, which, at 140 fathoms deep, divides into two veins. The *heaves* have been already particularized.[1] Those by the western vein, both at 150 and 170 fathoms deep, are 30 feet; and of the *heaves* by the eastern, the distance is 9 feet at 150 fathoms deep, 5 feet at 170 fathoms, and 7 feet at 180 fathoms. All the *heaves*, whether by the whole *cross-course*, or by its separate veins, are towards the left hand. By *Woolf's cross-course*, however, the same *lode* is *heaved* towards the right hand, and, on an average, about 50·5 feet. *Pl. V.*, *Fig.* 8.

(*m.*) At the *United Mines*, *Skues's flucan heaves* the *Old lode*, which dips north 60°—70°, 6 feet; a branch, which inclines south 70°—80°, 6 feet; a second branch, dipping 30°—40° in the same direction, 2 feet; the *Middle lode*, which is there perpendicular, 5 feet; *Michell's lode*, which dips south 70°—80°, 6 inches; a branch, which also dips south 70°—84°, 1 foot; and the *Mundic lode*, which dips

[1] *Ante*, p. 311.

north 60°—70°, 7 feet: all these *heaves* are towards the right hand. But it *heaves* in the opposite direction the following *lodes:—Bawden's south lode*, which dips south 60°—70°, 18 feet; three veins of *Bawden's lode*, which underlie south 70°—73°, each 18 feet; *Nicholls's branch*, dipping south 60°—72°, 18 feet; *Polkinghorne's lode*, which dips north 65°—76°, 6 feet; and, lastly, a branch which dips south 60—74°, 6 feet.

(*n.*) At *Herland, Wheal Bailey cross-course*, and *Chambers's eastern* and *western flucans heave* the *lodes* towards the left hand; whilst all the *cross-veins* west of them, which produce *heaves*, in the greater number of instances do so towards the right hand, but few of them to more than an inconsiderable extent.

(*o.*) At *Polladras Downs*, all the *lodes* dip northward, and the *flucan heaves* them all towards the right hand; but the distances are not generally alike for different *lodes*, or even for the same *lode* at different levels.

(*p.*) At 18 fathoms deep, in *Duffield*, the *eastern cross-course* simply intersects the *south lode*, whilst it *heaves* the *Little north lode* 9 feet towards the left hand; between these *lodes*, however, *Holman's lode* intersects the *cross-course*, and *heaves* it 3 feet towards the left hand. All the *lodes* have a northerly inclination.

(*q.*) At *Fowey Consols*, the *cross-course* simply intersects *Bone's* and *Jeffery's lodes*; it next *heaves Crosspark lode* towards the right hand, but different distances at different depths: *Williams's lode heaves*

the *cross-course* 4 feet towards the left hand; the *cross-course* then intersects *T'rathan's lode*, and at some levels *heaves* it towards the right hand; and, lastly, it *heaves* the *Black lode* 11 feet towards the left hand.

(*r*.) At *Tincroft*, the *Old lode* dips northward, and simply intersects the *eastern cross-course*. The same *cross-course* then *heaves Highburrow lode*, which dips south, 1 foot towards the right hand; it next intersects a mass of granite, and also an *elvan-course* which dips northward, but *heaves* neither of them. It then crosses two granite veins, one dipping north and the other south, and afterwards *Martin's lode*, which dips north, *heaving* all three towards the right hand. On meeting *Dunkin's lode*, at 26 fathoms deep, the *cross-course* is *heaved* 4 feet towards the right hand; whilst, at 84 fathoms, the same *cross-course heaves* the same *lode* 4 feet also towards the right hand; and, lastly, the *cross-course heaves* the *south lode*, which dips northward, 2 feet in the same direction.

Thus the *heaves* of two *lodes* by the *cross-course* lie between two intersections of the same *cross-course* by two other *lodes*; whilst one of the intersections of the *cross-course* by a *lode* is included between two *heaves* of *lodes* by the *cross-course*. *Pl. VI., Fig.* 6.

(*s*.) In the well-known case at *Dolcoath*[1] (*Pl. VI.*,

[1] This most important series of intersections was first brought under my notice by the kindness of Capt. Petherick. It is figured in Dr. Boase's "Primary Geology," p. 190, fig. 23; and it has also been described by me, Edin. New Phil. Journal, xxii. (1836), p. 168; and Report of the British Association (1837), p. 74.

Fig. 2), *Entral north lode heaves Wheal Bryant cross-course* 9 feet towards the right hand; the same *cross-course heaves* two veins, one 12 and the other 30 feet towards the right hand, and the western portion of the latter is in *elvan*, whilst the eastern is in slate: the *cross-course* traverses but does not *heave* the *elvan-course*.

In the same mine, at 56 and 76 fathoms deep, the *Caunter lode heaves Harriette's lode*, respectively, 6 feet and 4 feet; but, at 96 fathoms, *Harriette's lode heaves* the *Caunter lode* 90 feet, and, at 116 fathoms, 120 feet (*Pl. VI., Fig.* 3,).

(*t.*) The *Carbona*, at *Saint Ives Consols*, has been already described,[1] and also its intersection by the *Middle trawn*.[2] It is necessary, however, to repeat here a few particulars. At 80 fathoms deep, the *Carbona*, deviating from its usual direction (S.E.), takes that of the *Middle trawn*, and accompanies it for 25 fathoms. Within a few fathoms of this junction the *trawn* partakes of, and indeed almost assumes, the mineral character of the *Carbona*. The *Carbona* then strikes off in a N.E. direction, and leaves the *trawn*, which soon resumes its original composition. The *Carbona*,[3] on the eastern side, is enormously larger than on the western side of the *trawn*.

(*u.*) At *Wheal Providence*, the *eastern flucan*

[1] *Ante*, p. 21. [2] *Ante*, p. 312.

[3] In this most interesting spot some very curious formations of quartz have been lately found. They seem as if they had originally enclosed hexagonal prisms; and these being removed, there remain cups formed of quartz, coated both within and without with small pyramidal crystals of the same substance.

heaves the *Caunter lode* 6 feet towards the right hand at 30 fathoms deep, and 10 feet towards the left at 48 and 58 fathoms.

(*v.*) At 12 fathoms deep, in *Wheal Robert*, the *cross-course heaves* the *Ore lode* 6 feet towards the left hand, and, at 24 fathoms, 18 feet in the opposite direction.

(*w.*) At *West Pink*, the *Lead vein heaves Carrow's Gossan lode* 5 feet towards the left hand at 25 fathoms deep; but, at 59 fathoms, *Carrow's Gossan lode heaves* the *Lead vein* 60 feet towards the right.

(*x.*) At the *Morvah* and *Zennor Mines*, the *lode* and *north-course* twice intersect each other.

(*y.*) At 112 fathoms deep, in *Great Work*, the *cross-course heaves Wheal Breage lode* 1 foot to the left hand, and at 132 fathoms simply intersects it; whilst, at an intermediate spot (122 fathoms), the *lode* divides the *cross-course*, although it does not *heave* it.

(*z.*) At *Trevaskus*, the *lode* intersects both the *eastern* and *western cross-courses*, but it *heaves* neither of them.

(*aa.*) At *Wheal Trannack*, the *cross-course*, at 34 fathoms deep, is perpendicular, and is *heaved* 2 feet towards the left hand by the *lode*; at 64 fathoms it is also perpendicular, and there it is simply intersected; whilst, at 74 fathoms, it dips east 84°, and is again *heaved* by the *lode* 9 feet towards the left hand.

(*bb.*) At the *Marazion Mines*, *Godolphin*, and *Dolcoath*, some of the *cross-veins*, which do not appear at the surface, at certain depths below *heave* the *lodes*.

(*cc.*) At *Relistian*, on the other hand, the *flucan*, from the surface to 125 fathoms deep, intersects, and in one spot *heaves*, the *lode*; but, beneath that level, it wholly disappears.

(*dd.*) At *Wheal Buller*, the *cross-veins*, which intersect some *lodes*, although cutting them at all depths, do not reach to other parallel *lodes* at very small distances from those intersected.

(*ee.*) At *Poldory (United Mines)*, several small *flucans* intersect and sometimes *heave* the *lodes*; but they do so only in certain parts of their descent, and not only disappear upwards and downwards, but are also of very short lengths, for those which intersect one *lode* seldom extend to any other:—certain *cross-veins* being, as it were, peculiar to some *lodes*, and not continuing far from them.

(*ff.*) At *Polgooth*, *Reskilling Great elvan heaves* both *Saint Martin's* and *Screed's lodes*, whilst *Saint Martin's lode* intersects the *Little elvan*, which in every respect but its size resembles *Reskilling Great elvan*.

(*gg.*) The only other class of facts which seems to bear on this enquiry, but the evidence of which is of an inferential kind, is that comprizing the *heaves* of the *lodes* at *Balnoon* and *Dowgas*, which take place without the intervention of a joint of rock,[1] or of a *cross-vein*, or any other intersecting body whatever.

Let us now proceed to consider how far these

[1] Dr. Boase, Corn. Geo. Trans., iv. p. 448.

heaves and intersections can be reconciled with any assumed motions; either on real planes, as those of the *cross-veins*, or on imaginary ones adopted for the sake of argument alone.

If we grant that the formation of *lodes* was prior to that of *cross-veins*,

I. *The intersection of a single lode by a single cross-vein*, whether the result be a simple intersection, or a *heave* to the right hand or to the left, is easy of solution.

A simple intersection might be effected by the mere opening of a fissure, and the introduction into it of materials forming a *cross-vein*. Or, if the *lode* were perfectly straight in its descent, the same result would be produced by the elevation of the portion of the *lode* (and of course of the containing rock also) on one side of the *cross-vein*, or by the subsidence of that on the other:—provided that the motion took place in a direction parallel to the dip of the *lode*; as, for example, a vertical motion and a perpendicular *lode*. But *lodes* are never perfectly straight, but are curved and irregular when seen in profile.

If, then, there be either an elevation of one side of a *cross-vein*, or a depression of the other, it would be a circumstance scarcely to be deemed accidental that the curvatures should occur in such regularly recurring and perfectly similar series, and that the degree of motion should be so adapted to them, that one of them should be raised, or the other lowered, so as to preserve a perfect coincidence with another,

and thus retain the continuity which, in its primal state, had existed at a different level. Yet these coincidences (if either vertical or oblique motion has ever taken place) form 22·7 per cent. of the total number of intersections.[1]

Again, the *heave* of a *lode* by a *cross-vein* may be occasioned either by a horizontal, vertical, diagonal, or curvilinear motion of the portion on either side, or on both sides, of the *cross-vein.*

(1.) A simple horizontal motion will occasion an equal displacement at all depths, which almost every fact we have considered *(b, i, j, k, l, &c.,)* shows to be rarely, if ever, the case.

In all other kinds or directions of motion the extent or distance of the *heave* (displacement) depends on the angle included between the line of dip of the *lode,* and that of the direction of the motion, and also on the extent of the motion.

(2.) Let the superfices AB, A^1B^1, A^2B^2, *Pl. XII., Fig.* 1, 2, respectively, be the surface or ground-plan, supposed to have formerly been at one level; YZ, Y^1Z^1, Y^2Z^2, the vertical planes exposed by the respective subsidences of A^1B^1, and A^2B^2:—a, a^1, a^2, the superficial portions of the same vein which were originally united at the same level; and b, b^1, b^2, the profiles or transverse sections, which show the inclinations, or downward courses, of the respective parts.

Now, supposing the original state restored, and AB, A^1B^1, A^2B^2, to be on the same level; let us

[1] *Ante*, p. 286.

imagine a fracture to take place in the direction $w x$, and at the same time the portions A^1B^1, and A^2B^2 (which are still united) to subside on the line or in the direction $o p$. It is obvious that the portion or end of the *lode* a^1 in the subsided portion A^1B^1, A^2B^2 (by subsiding in the direction $o p$, instead of $o q$, which is the dip of the *lode*), will not be found at p in contact with $o b q$, the portion of *lode* contained in the mass of rock AB, YZ. Therefore the *lode* has suffered a *heave* towards the right hand, the extent of which is the distance $p q$; and, as the *lode* is straight, this extent is the same at all levels.

We will now suppose a second fissure to be formed on the line $y z$, and the portions of rock AB, and A^1B^1, with the *lode* they contain, to be stationary, and the mass A^2B^2 to subside still further, but that the line of subsidence is now parallel to the dip of the *lode* b^1, in the direction of $r s$, instead of being oblique to it, as in the last instance. As the dip of the *lode* is perfectly uniform, the superficial portion a^2 will continue in contact with b^1 at s, and consequently there will be no *heave* at that point.

It needs but little consideration to discover that the very same results must be necessarily obtained whether AB be the fixed mass, and A^1B^1, A^2B^2, subside; or whether A^2B^2 be the stationary portion, and A^1B^1, AB, are elevated: provided only that the lines of motion be still $r s$ and $o p$, respectively.

Neither will it require much inspection to see that it does not signify whether the motion $o p$ be vertical or diagonal; for a *heave* must of necessity

take place whenever the lines of motion and of dip do not correspond: and, this being the case, the greater the extent of elevation or subsidence, the greater will be the distance of the *heave*.

On the other hand, it is equally clear that if the *lode* be perfectly straight, and the lines of motion of the mass and dip of the *lode* coincide, as in *r s*, the amount of the motion is immaterial; for whatever it may be, no *heave* can possibly take place so long as this correspondence continues.

Let us now examine a case in which the dip of the *lode* shall be irregular, and see what should be the direction of the motion which would occasion simple intersections at some levels and *heaves* at others, but all the *heaves* in the same direction.

Now it is evident, that with a vertical motion *o p* (*Pl. XII., Fig.* 3), no very obliquely inclined vein can ever be simply intersected at one part of its downward course and *heaved* at another; for, if the direction of the dip remain the same, the direction of the movement tends to separate the severed portions at all parts of their descent. And the lower part of the elevated portion can be brought into contact with, or opposition to, the upper portion of the stationary one so as to cause a simple intersection, only by a change in the direction of the motion, or by reversing the dip of the *lode*.

If, however, the dip be in opposite directions, in different parts of the *lode's* descent, then not only may a vertical movement of the portion on one side of the fissure (or *cross-vein*) produce simple inter-

sections at some depths and *heaves* at others, but the *heaves* at different levels may even be in opposite directions; and this is, of course, the more likely to occur the closer the approach to parallelism between the dip of the *lode* and the direction of the motion.

Let AB (*Pl. XII., Fig.* 4,) denote the original position of the surface, and *a b b* the *lode* in its original place, some parts of it dipping north, others south. Let A^1B^1 be the present position of the surface which has been elevated from the level of AB, and $a^1 b^1 b^1$ the portion of the *lode* contained in the mass A^1B^1. Let it also be supposed that A^1B^1 stands beyond AB, as well as above it; and that they are separated by a *cross-vein*: and also that the motion has been a vertical one from *p* to *o*. Then at the surface of AB the *cross-vein* will simply intersect the *lode*, and will continue to do so as far downward as *b*: from *b* to b^1 the further or elevated portion will stand on the right of the unmoved one, and, consequently, from *b* to b^1 the *heave* will be in that direction, although differing in extent at different levels. As portions of the *lode* with opposite inclinations are, in consequence of the elevation, opposed to each other on different sides of the *cross-vein*, at b^1 these severed portions, when viewed in profile, will appear to cross each other, and at that point a simple intersection will again occur. Below b^1, however, the elevated portion will be on the side opposite to that which it occupied above:—in fact there will be a left-hand *heave* below the point b^1, and a right-hand *heave* above it.

Though a simple case, this is, however, one of very uncommon occurrence; for I have met with but three examples[1] of *heaves* of the same *lode* by the same *cross-vein*, which are in opposite directions at different levels: viz., at the *United Mines*, *Wheal Robert*, and *Wheal Providence* (*i*, *v*, *u*,), and as they form so small a proportion, it seems scarcely necessary to pursue this point further.

(3.) Instead of a vertical motion we will now consider one on a line passing through the various flexures of the *lode*, and which shall, in fact, be coincident with its mean dip.

Let AB (*Pl. XII.*, *Fig.* 5,) be the level of the surface originally, A^1B^1 that to which that portion of it has been elevated: *a*, *b*, *b*, *b*, the *lode* in the former, and a^1, b^1, b^1, b^1, that in the latter, curved as it descends in both: *p o* the direction of the motion. It is obvious, that as *a*, *b*, *b*, *b*, and a^1, b^1, b^1, b^1, were originally united and continuous, their configuration must be alike; and that, during the motion of A^1B^1 with the *lode* contained in it, several of the sinuosities of the latter must have passed similar ones in the former; until finally from *a* to b^1 the *heave* is towards the right hand: at b^1 the *lodes* cross, and there is a simple intersection only; from b^1 to *b* the *heave* is towards the left hand, and at *b* there is a second simple intersection; from *b* to b^1 the *heave* is again to the right, and at b^1 a third simple intersection occurs; from b^1 to *b* there is again a right-hand

[1] Mr. Carne describes a case of the kind at *Gunnis Lake* (Corn. Geo. Trans. ii. p. 99), and another is said to have occurred at *South Wheal Towan*.

heave (for at b^1 the two parts of the veins merely stand opposite to each other, and do not *cross)*; at *b* there is a fourth simple intersection; and thence downward there is a left-hand *heave*. This iteration of contradictory phenomena is thus obtained with no greater flexures, in a direction contrary to the general dip, than are common in *lodes*. But, although these slight reverses often occur, a reversed dip for any great extent is very unusual; and such contradictory *heaves* are entirely unknown in Cornwall.

(4.) We will now see how far the results of curvilinear motion will agree with observation.

The centre of motion must be either at the surface, or at some point beneath it.

If *at the surface*, there must necessarily be a simple intersection at that spot *(a, Pl. XII., Fig.* 6); whilst, at every inferior station, there must be a *heave*, and the distance of the *heave* will increase directly as the depth.

The same state of things, but in a reversed order, must also take place should the centre of motion be at *some point beneath our reach;* for in such a case the *heave* must be a maximum at the surface, and diminish as we approach the centre.

In either case all the *heaves* will be in the same direction at all depths.

If, however, the centre of motion be at some point *below the surface* (but one which has been reached by mining), as at *x, Pl. XII., Fig.* 7; then at that point will there be a simple intersection, and at every other a *heave*. Here, also, the extent of the *heave*

must, of course, increase the further it is situated from the centre of motion; whilst all the *heaves* above that point will be in one direction, and all those below it in the other. Thus, if we suppose the portion a^1, b^1, of the *lode* to be further from us than $a\ b$, then the *heave* above x will be towards the right hand, and that below it towards the left.

It has been already stated[1] that we possess but three examples of the *heaves* of the same *lode* by the same *cross-vein*, which are in opposite directions at different levels: two of these (i, v,) have been observed at only one spot above, and another below, the neutral point (x): in the third,—*Wheal Providence*, although the direction of the *heave* is reversed between 30 and 40 fathoms deep, yet at 58 fathoms its extent is the same (10 feet) as at 48 fathoms.

Thus, of the three facts (i, u, v,), to which alone this solution can possibly apply, two do not furnish sufficient evidence to determine its application, and the third is inconsistent with it.

(5.) What then must be the conditions of dip and motion, in the *heave* of a single *lode* by a single *cross-vein*, that will occasion simple intersections at some levels, and *heaves* at others; whilst, at the same time, all the *heaves* shall be in the same direction?

We have seen that neither a horizontal (1), vertical (2), nor curvilinear (4) motion, nor one coincident with the mean dip of the *lode* (3), will satisfy the conditions demanded by the greater number of

[1] *Ante*, p. 314.

facts. Let us now assume a motion which, in a single case at least, seems likely to comply with them all: although there seems no reason for presuming on its existence, but that, in the case of individual intersections taken singly, it will comply with many of the facts.

Let AB (*Pl. XII., Fig.* 8,) denote the original position of the surface, *a*, *b*, *b*, the *lode*; A^1B^1 the new one to which the piece beyond AB, including the *lode* a^1, b^1, b^1, has been elevated; and *p o* the line of motion, which includes such an angle with the dip of the *lode* as to remove every part of a^1, b^1, b^1, so far from the general position of the unmoved portion, that only the more prominent parts of both the segments shall be in contact when they are brought into direct opposition. It is at these salient points only, as at b^1, b^1, that there is a simple intersection; whilst, at all other parts of the downward course, the *heave* is towards the left hand.

We have already seen (3) that no motion parallel to the dip of the *lode* will satisfy the conditions before us; though oblique motion, within given limits, will afford an explanation. Yet, as the extent of the *heave* depends on the amount of the motion, if that amount be unlimited, the mean distances of the *heaves* must progressively increase as they recede from a given point: a state of things which is not found to prevail.

It is obvious that if the line of motion always includes an angle with *the same side* of the *lode*, the *heave* at all levels must be in the same direction.

If, however, the line of motion pass through the undulations of the *lode*, leaving some of them on one side of it, and some on the other, the *heave*, as previously shewn (3), will also, of necessity, be sometimes towards one hand, and sometimes towards the opposite.

II. Let us now apply to the intersections of two or more *lodes*, or other veins, by the same *cross-vein*, the same laws which have been assumed to prevail when there is but a single intersection.

(1.) In the event of a horizontal movement, any number of veins contained in the mass of rock displaced, should be always *heaved* to the same distance in every instance, and for the same extent at all levels: but this result never occurs (*a, d, e, f, g, h, i, m*, &c.).

But, although a horizontal motion will not accurately apply, as its results will not agree with the order observed; it will, nevertheless, produce effects bearing a nearer resemblance to the facts than those following motion in any other direction. In short, where two or three *lodes* are intersected by the same *cross-vein*, 70·2 per cent. of the total number are *heaved* in the same direction; whilst less than one per cent. is *heaved* to the opposite side. On the other hand, of the *cross-veins* which traverse two or three *lodes* each, 8·8 per cent. simply intersect one of the *lodes*, and *heave* the rest. And in almost innumerable instances, as at *Dolcoath*, *Cook's-kitchen*, the *United* and *Consolidated Mines*, *Cardrew Downs*, &c. (*s, c, i, e*, &c.), the same *cross-veins* traverse both

elvan-courses and *lodes;* and, whilst the former are simply intersected, the latter, on either side of them, are *heaved.*

Notwithstanding the greater number of *lodes heaved* by the same *cross-veins* is *heaved* in the same directions, it seldom or never happens that both, or all, of them are *heaved* the same distance; which is utterly incompatible with the supposition of their having originated in horizontal movements (*d, e, f, g, h, i, j, k, l,* &c.).

(2.) If two *lodes,* with opposite inclinations, be transversely fractured, and one of the segments vertically elevated, whilst the other remains unmoved, the *lodes* must be *heaved* in opposite directions at all levels. This is a physical necessity, and it is utterly impossible that any other result could follow such conditions.

Let AB, *Pl. XII., Fig.* 9, 10, be the surface of a a given tract in its original position, A^1B^1 that of another which formerly stood at the same level with, and was united to, AB, but which has since been elevated vertically, and which now stands beyond AB. YZ is a transverse section perpendicular, or nearly so, to AB, and Y^1Z^1 a similar one, in like circumstances with regard to A^1B^1.

Let also a, a^1, represent the superficial parts of one vein or *lode,* and b, b^1, its deeper portion; c, c^1, the upper parts of another vein, and d, d^1, the lower. The two portions, respectively, of either vein must be presumed to have been originally united and continuous, but to have been severed at the *cross-vein*

w x, fig. 10. The inclinations of the two veins, it must be observed, are in opposite directions.

We will suppose the original state of things restored; AB, and A^1B^1, on the same level, and *a*, a^1, and *c*, c^1, respectively, united. Let A^1B^1 be now perpendicularly elevated from *p* to *o*. This movement will bring a portion of the lower parts of the *lodes*, where by their dips towards each other they are closer together, opposite the upper portion where they are further apart.

Such a motion will evidently break the continuity of both; and thus, if the portion above *p*, on the line *w x, fig.* 10, were removed by denudation or any other cause, the surface then presented would be that depicted in the plan (*fig.* 10). In short, one *lode* would be *heaved* towards the right hand, as *a*, a^1, and the other to the left, as *c*, c^1. These results are not mere probabilities, but physical necessities, which, and *which alone*, must inevitably follow a vertical elevation of portions of *lodes* having opposite dips.

In this case, too, there can never be a simple intersection unless the dip is reversed: and not even then, unless the elevation be to such an extent as will directly oppose to each other portions which have these opposite inclinations.

The examples, therefore, in which *lodes* with opposite inclinations are *heaved* in the same directions (*a, b, c, d, e, f, g*, &c.), as well as those in which there are *heaves* at some levels, and simple intersections, without reversed dips at others (*b, n, q*,), are

equally unaccounted for on this hypothesis. The insufficiency of its general application is also most decided in all cases where the *cross-vein heaves* the *lodes*, but simply intersects the *elvan-courses* which lie between them (*e*, *f*, *g*, *i*, *p*, &c.). These contradictions, between fact and theory, nothing can reconcile.

(3.) Let us now take an example in which, as in the last, there are two veins having opposite inclinations, with a third vein between them which dips in the same direction as one of the others, but at a different angle. Let the assumed motion be parallel to the dip of the latter.

I put this as a case which, in some respects at least, satisfies the conditions left unsolved by the last: viz., two *lodes*, having opposite dips, being *heaved* in the same direction, whilst a third (an *elvan-course)* occurring between them is simply intersected.

Let AB (*Pl. XII., Fig.* 11, 12), as in the last case (2), be the unmoved surface, and A^1B^1 the elevated one; YZ the unmoved transverse section, and Y^1Z^1 that which has been raised:—*a*, a^1, and *c*, c^1, the superficial parts of the same *lodes*, which, when at the same level, had been respectively united; and *e*, e^1, the upper portions of the *elvan-course*, once united, and still *unheaved*: *b*, b^1, *d*, d^1, and *f*, f^1, the deeper parts of the three veins respectively.

Now, if A^1B^1 be further from us than AB, and if we suppose it to be elevated on the line *s r*, parallel to the dip of *f*, f^1, and the superficial portion above

AB removed as before described; the plan, *fig.* 12, will present an idea of the new state of things; the *cross-vein, w x,* having been formed during the elevatory action.

w x will break the continuity of a, a^1, and c, c^1, and *heave* both of them; whilst, as the motion upward, on the line *s r*, parallel to f^1, will keep *e* and e^1 still in contact at all levels, and the dip remaining the same, this third vein will be simply intersected.

Now, as *e* dips in the same direction as *c*, although not at the same angle, whilst *a* has an opposite inclination, it is evident that as the movement is parallel to f^1, that vein will suffer no *heave;* and that as the dip of *c* forms a smaller angle with f^1 than (*b*) the inclination of *a* does, the *heave* of *c* will be of smaller extent than that of *a*.

The line of motion (*s r*) being oblique, and flatter than d, d^1, will in this instance occasion the *heave* of *c* to be towards the right hand as well as that of *a*, instead of their being in opposite directions, as would be the effect of a vertical motion.

This agrees with the facts much better than the hypothesis of a vertical movement: but we can arrive at no positive proof of the sufficiency or insufficiency of its application to a full explanation of the observed phenomena of *heaves*, unless by comparing the actual motions which would be imparted to a^1 and c^1, in examples where it is supposed to have been parallel to the dip of the *unheaved* vein.

If the same *cross-vein* traverse several veins, and simply intersects one of them whilst it *heaves* all the

others, and if these displacements have been occasioned by an elevation of one side of the *cross-vein*, or a subsidence of the other, it is evident that the *direction* of the movement must have been parallel to the dip of the vein which is not *heaved:* and what may have been the *extent* of the motion is determined by the distance of movement, in the beforenamed direction, requisite to produce *heaves* of the extent observed. In other words, the *direction* of the motion is from *s* to *r*, *fig.* 11: and, in order to obtain the *heaves*, a, b^1 and c, d^1, *fig.* 11, or a, a^1 and c, c^1, *fig.* 12, its extent must also be the distance, *s r*. Thus, the *unheaved* vein indicates the *direction*, and the *heaved* one the *extent* of the motion.

We will now compare the observed phenomena with this test, in order to see whether a movement parallel in direction to the dip (f, f^1,) of the vein simply intersected, and of the distance, *s r*, whilst it produces the observed *heave*, a, a^1, *fig.* 12, will, by a motion similar both in direction and extent, occasion at c, c^1, a *heave* which shall correspond with observation in every particular: or, on the other hand, whether a motion, in the same direction, and in distance sufficient for the production of the *heave*, c, c^1, will at the same time *heave* a, a^1 in such a direction, and to such a distance, as the actual fact presents.

(A.) At the *Consolidated Mines* (*Table* LXII.), *Tiddy's* or *Paul's cross-course* intersects without *heaving* an *elvan-course*, which dips N.E. 50°, and also *Glover's lode*, which dips S. 50°—80°; whilst it *heaves Paul's lode*, which dips N.W. 50°—70°,

from 15 to 18 feet at different levels, and *Michell's lode*, which dips S. 80°, 3 feet, and both of them towards the right hand (*i*).

We have here two veins, the *elvan* and *Glover's lode*, dipping in opposite directions, and both simply intersected; and two others which have also opposite inclinations, and are, nevertheless, *heaved* in the same direction, but to unequal distances.

Now, a horizontal motion (1) would have *heaved* them all the same distance, and in the same direction; and a vertical movement (2) would have *heaved Glover's* and *Michell's lodes* in one direction, and the *elvan-course* and *Paul's lode* in the opposite: whilst a motion on the line of inclination of *Glover's lode* would have occasioned a *heave* of the *elvan-course*, as well as of *Paul's* and *Michell's lodes;* on the other hand, if the line of elevation or subsidence had coincided with the dip of the *elvan-course*, it must inevitably have *heaved Glover's lode* (which has an opposite dip to the *elvan*), together with *Michell's* and *Paul's lodes.*

We have thus, within a very few fathoms, two sets of facts equally contradictory to each other, and to all the directions of motion we have yet assumed: nor does any circumstance indicate that any other motion could be substituted with greater probability of overcoming the difficulty.

(B.) At *Cardrew Downs*, two *elvan-courses* dip W. 50°—60°: both of them are intersected, both by the *Little* and the *Great flucans*, but they are not *heaved* by either. The *south lode* dips N. 60°—80°, and the

north lode dips S. 68°—82°. The *Little flucan heaves* the former 24 feet at 50, and 60 fathoms deep, and 30 feet at 100 fathoms; and the latter 15 feet at 50, 70, and 80 fathoms deep, and 12 feet at 60 fathoms. All the *heaves* are towards the right hand.

Now, if the *heaves* had been consequences of horizontal motion (1), not only would all of them have been of the same extent, but the *elvan-courses* would have been *heaved* as well as the *lodes*. If the motion had been a vertical one (2), the *lodes* would have been *heaved* in opposite directions, and both the *elvans* would have been *heaved* also. As, however, the *elvans* are not *heaved*, any motion must have been parallel to their inclination (*s r*, *Pl. XII.*, *Fig.* 11). Now, in order to produce a *heave* of 24 feet at the *south lode* by an elevation parallel to the dip of the *elvan*, a movement of from 25 to 30 feet in extent is requisite; whilst a motion, similar in direction and distance, would produce a *heave* of between 5 and 6 feet in the *north lode*, whereas the observed *heave* is 15 feet. This discrepancy between the computed and observed results is surely inconsistent with accidental fluctuation (*e*).

(C.) At *Wheal Unity Wood*, the *Great elvan-course* dips N. 40°—50°; *Trefusis lode* also dips N. 66°—82°; the *Little Ore lode* likewise dips N. 52°—60°; and *Pits-an-vollar lode* inclines in the same direction 60°—70°. The *flucan* simply intersects the *elvan-course;* whilst it *heaves Trefusis lode* 36 feet at 26 fathoms deep, and 30 feet at 36 fathoms; —the *Little Ore lode* 12 feet at 60 fathoms deep,

and *Pits-an-vollar lode* 21 feet at the same level. In all these cases the *heaves* are towards the left hand.

The elevatory action, if any, must, of course, have been parallel to the dip of the simply-intersected vein,—the *elvan.* Now, in order that a motion in this direction should produce a *heave* of 36 feet in *Trefusis lode* at 26 fathoms deep, the extent of the movement must be from 85 to 90 feet; whilst, to produce a *heave* of 30 feet, in the same lode, at 36 fathoms, a motion of only about 55 in the same direction would be requisite. But an elevation of 90 feet, in a direction parallel to the underlie of the *elvan,* would produce a *heave* of 21 feet in the *Little Ore lode* at 60 fathoms deep, and one of 55 feet would occasion a *heave* of 12 feet; whereas the same quantities of motion, acting in the like direction on *Pits-an-vollar lode* at 60 fathoms, would respectively cause *heaves* of 45 and 27 feet.

Thus, in order to the production of the observed phenomena, we have at *Trefusis lode* these scarcely compatible conditions:—either the direction of the motion was the same at both, and its extent different, or that the extent of motion was the same at both, and its direction different.

The same extent and direction of motion which will produce the *heave* observed in *Trefusis lode* at 36 fathoms deep, will also give the real *heave* of the *Little Ore lode* at 60 fathoms; whilst the extent of motion necessary to obtain the *heave* of the former at 26 fathoms deep, will occasion a *heave* of 21 feet in the latter; being an excess of 9 feet over the observed distance.

If the motion at *Pits-an-vollar lode* at 60 fathoms deep were of similar direction and extent to that assumed to have acted on *Trefusis lode* at 26 fathoms deep, the *heave* would have been 45 feet; or, if the same as that at 36 fathoms, it would have been 27 feet. Now the observed *heave* is 21 feet; and, in order to obtain this with a motion parallel to the *unheaved* vein (the *elvan*), an elevation of about 40 feet would have sufficed: and such a degree of motion, at the same depth, would have occasioned a *heave* of about 9 or 10 feet in the *Little Ore lode*, instead of the observed distance of 12 feet (*f*).

In the foregoing examples the *elvan-courses* are the simply-intersected veins: it may now be desirable to examine a few in which the *unheaved* veins are *lodes*.

(D.) At *Fowey Consols*, at 90 fathoms deep, the *cross-course* simply intersects *Bone's* and *Jeffery's lodes;* but, at 95 fathoms, where *Crosspark lode* is in two veins, it *heaves* one of them 9, and the other 15 feet towards the right hand, and at 200 fathoms, where there is only one *lode*, it is *heaved* 2 feet in the same direction (*q*).

The vein of *Crosspark lode*, which in dip most closely approximates to the *unheaved lodes* (*Bone's* and *Jeffery's*), is *heaved* further, whilst the other vein, which differs most from them in inclination, is *heaved* the smaller distance; and yet the difference in the inclinations of these veins is only about three degrees. Now, taking their mean dip and the direction of the movement to be parallel to *Bone's* and

Jeffery's lodes, the extent of motion requisite to produce a *heave* of 9 feet would be about 26 fathoms; but, to obtain a *heave* of 15 feet, an elevation of nearly 39 fathoms in the same direction would be requisite. Applying these directions and extents of movement to the *lode* at 200 fathoms deep, where it has a flatter inclination, a motion of 26 fathoms would cause a *heave* of 30 feet, and one of 39 fathoms a *heave* of 39 feet: the actual *heave*, however, is only 2 feet.

Here, then, we have, in one case, that *lode heaved* furthest which, according to the theory, ought to have been *heaved* the least; and, in the other, a *heave* of only 2 feet, whereas the hypothetical motion demands one of 30 or 39 feet.

For the present I pass the consideration of the *heave* of this same *cross-course* by *Williams's lode*, as it will be again necessary to advert to it (V.–3).

(E.) At *Stray Park*, the two *lodes* have opposite dips, and both are intersected by the same *cross-courses*. Now a horizontal motion (1) would have caused similar *heaves* in both *lodes* at all levels. A vertical motion (2) would have caused them to be *heaved* at all levels, and everywhere in opposite directions. Any movement, parallel to the dip of one of them (3), would, for the most part, have simply intersected, or at any rate but slightly *heaved* it;[1] whilst its effects on the other *lode* would have been much greater. Lastly, a rotatory motion (4) would have produced results, constantly increasing in mag-

[1] In consequence of the *lode's* dip not being perfectly uniform.

nitude as the spot was more remote from the neutral point or centre of motion.

Let us compare these demands of theory with the facts observed:—At

108 fms. deep, both *lodes* are simply intersected by one *cross-course*.
102 ,, both *lodes* are *heaved* to the left hand by one *cross-course*, and to the right by the other.
178 } ,, both *lodes* are simply intersected by both *cross-*
188 } *courses*.
198 ,, both *lodes* are simply intersected by one *cross-course*.

Similar results, at the same levels in both *lodes*, whether intersected by one or both of the *cross-courses*, appear in every instance; except at 146 fathoms deep, and there one *lode* is simply intersected, whilst the other is *heaved* towards the left hand.

These facts seem utterly irreconcilable with the result of motion in any one single direction that can possibly be assumed.

But we have not always simple intersections to indicate the directions in which any elevatory forces must have acted. In the absence of the guidance such examples afford, it will be requisite to ascertain whether the observed conditions may or may not be fulfilled by motions which are neither horizontal, vertical, nor yet coincident with the dips of any of the veins, but oblique to them all.

Very little consideration will convince us that *heaves* in the same direction, but of very different distances, may in this manner be effected by motion of the same extent and direction; as it will act on the *lodes* according to the coincidence or obliquity between their dips and the direction of the movement.

Such a state of things, arbitrarily selected in order to suit the circumstances, may often be applied to the *heaves* of two *lodes* by the same *cross-vein*, when in the same direction, but of unequal distances. But the sufficiency or insufficiency of this hypothesis is tested by its affording, or not, in a third, fourth, or fifth intersection by the same *cross-vein*, the same coincidence between theory and fact as were obtained in the first and second.

(F.) At *Wheal Prudence*, an *elvan-course* dips N. 45°, and appears in the face of the cliff: the *north lode* dips N. 68°—80°, and the *south lode* dips S. 68°—85°. The *cross-course heaves* them all towards the right hand,—the *elvan-course* 30 feet, the *north lode* 9 feet, and the *south lode* distances differing at different levels, and varying between 18 and 30 feet (*g*).

A horizontal motion would have *heaved* all the veins to the same distance; a vertical movement would have *heaved* the *south lode* in a direction opposite to the others; and a motion coincident with the dip of either would have occasioned a simple intersection of that vein, and *heaves* in the other two: all which results are opposed to the facts.

Now an elevation on a line which might dip northwards about 87° from the horizon, would, by an equal extent of motion (about 34 feet in both cases), occasion a *heave* of 30 feet in the *elvan-course*, and one of 9 feet in the *north lode*, both of which accord with observation. When, however, we apply the same extent and direction of motion to the *south*

lode, the discordance between fact and theory becomes most obvious, and is shown below :—

Depth.	*Calculated dist.*	*Observed dist.*
80 fms.	14 feet.	30 feet.
92 ,,	14 ,,	18 ,,
100 ,,	12 ,,	30 ,,
110 ,,	12 ,,	21 ,,

The failure of this attempt at theoretical explanation can scarcely be rendered more striking.

(G.) At *Polladras Downs*, all the *lodes* dip N.:—the *Bor lode* 56°—80°; *Bissa lode* 50°—82°; *Pressure north lode* 56°—74°; *Pressure south lode* 56°—82°; and *Richards's lode* 72°—76°. The *flucan heaves* them all towards the right hand (*o*).

The inclination of a line on which a given extent of motion will produce the greatest number of results approximating to the observed facts, is about 85° towards the south (from the horizon); and the extent of the motion required is about 17 or 18 fathoms. The differences between the calculated and observed distances of the *heaves* are as follow :—

	Depths.	*Calculated dist.*	*Observed dist.*
Richards's lode ..	13 fms.	42 feet.	42 feet.
Pressure S. lode ..	33 ,,	42 ,,	42 ,,
,, ..	43 ,,	40 ,,	42 ,,
,, ..	53 ,,	43 ,,	72 ,,
,, ..	83 ,,	60 ,,	42 ,,
Pressure N. lode ..	33 ,,	45 ,,	24 ,,
,, ..	83 ,,	78 ,,	72 ,,
Bissa lode ..	43 ,,	84 ,,	84 ,,
Bor lode ..	73 ,,	42 ,,	12 ,,
,, ..	83 ,,	42 ,,	12 ,,
,, ..	93 ,,	53 ,,	18 ,,
,, ..	103 ,,	63 ,,	24 ,,

Thus, of 12 *heaves*, the assumed motions coincide in 3 instances, and differ from the observed results in the remaining 9.

If, on the other hand, preserving the direction of the motion, we assume its extent in each case to be equal to the production of the observed results, it will be as follows:—

	Depth.	*Extent of elevation.*
Richards's lode	13 fms.	17·5 fms.
Pressure S. lode	33 „	17·5 „
„	43 „	20·0 „
„	53 „	32·0 „
„	83 „	14·0 „
Pressure N. lode	33 „	8·6 „
„	83 „	16·0 „
Bissa lode	43 „	17·5 „
Bor lode	73 „	5·6 „
„	83 „	6·0 „
„	93 „	5·6 „
„	103 „	6·2 „

The differences here are certainly not less than in the first series of comparisons.

Let us still preserve the direction of the movement, but see the varying extents of it requisite to produce *heaves* of the same magnitude at all the points of observation. Let the extent of the *heave* be taken at 42 feet, which is about the mean in this mine:—

	Depth.	*Extent of elevation.*
Richards's lode	13 fms.	17·5 fms.
Pressure S. lode	33 „	17·5 „
„	43 „	20·0 „
„	53 „	18·0 „
„	83 „	12·2 „
Pressure N. lode	33 „	16·5 „
„	83 „	9·3 „
Bissa lode	43 „	9·5 „
Bor lode	73 „	17·5 „
„	83 „	17·5 „
„	93 „	14·0 „
„	103 „	11·3 „

At *Polberrow* (*h*) and the *United Mines* (*m*) similar differences occur.

The number of examples in which several veins are intersected by the same *cross-vein* is but few; in all of them, however, it will be found that no motion in one direction, and of the same extent, will restore the continuity of every vein so intersected:—and I must here repeat, that *the difficulty is in the connexion which subsists between them.*

(4.) A curvilinear motion is the only one now remaining for comparison with the facts observed. In order to ascertain the effect of such a motion, it is necessary to have particulars at different distances, on both sides of the presumed centre. These details may be either the directions and distances of *heaves* of different *lodes* at the same level, or of the same *lode* at several levels.

It has been already seen (4[1]) that a curvilinear motion will only apply to *heaves* which progressively increase in magnitude, or to those which are in opposite directions in the same vein at different depths, or at the same levels, if the veins be different.

No example of a progressive increase in the extent of a *heave* has been recorded.

At the *United Mines* (*m*), *Skues's flucan heaves* 7 *lodes*, which occur in regular sequence, towards the right hand; and 7 others, which also follow each other in succession, towards the left hand. Of the first seven, 2 dip towards the north, 1 is perpendicular, and 4 dip S.; of the second seven, 1 dips N. and 6 dip S.

[1] *Ante*, p. 352.

As all the *lodes* on one direction from a given point are *heaved* towards the right hand, and all those on the other towards the left, if this had been occasioned by a rotatory motion, the *lodes* furthest from the neutral point, axis, or centre of motion, would have suffered a movement progressively increasing in extent: consequently, the magnitude of the *heaves* ought to increase progressively as they are situated further from this axis, or point round which the motion has taken place. Now the four right-hand *heaves* which are furthest from this point are respectively 6, 6, 2, and 5 feet in extent, and the four left hand *heaves*, similarly situated, are two of 6 feet and two of 18 feet each; whilst the *lode* nearest to the point of division on one side is *heaved* 7 feet, and the corresponding one on the other 18 feet.

Thus, the *lodes* nearest to the neutral point are *heaved* further than those which are most distant:—facts in direct opposition to the theory.

III. *When the same lode is intersected by two cross-veins*, namely, a, a^1, a^2, by $w\,x$ and $y\,z$, *Pl. XII., Fig.* 13, if the portion a^1 contained between them be the only one moved, any motion, excepting one parallel to the dip of the *lode* a, a^1, a^2, must, necessarily, produce two *heaves* in opposite directions; for no motion of a^1 can possibly occasion a simple intersection by one *cross-vein* and a *heave* by the other.

Of 55 *lodes*, each traversed by two *cross-veins*, producing 110 intersections, there are 90 *heaves*.

Now this hypothesis would require that every *lode* should be *heaved* in opposite directions by the two *cross-veins* intersecting it; but this is the case with only 42 of them; and the remaining 48 are *heaved* in similar directions. Thus, 46·6 per cent. countenance the supposed law and 53·4 per cent. contradict it; and consequently the evidence against it preponderates.

Suppose, then, a series of *heaves* of the same *lode*, in the same direction, by different *cross-veins*: these must, therefore, be occasioned by successive steps; or the masses of rock which contain it must be supposed to have suffered a series of elevations each greater than the preceding: the first step being next to the unmoved rock. Thus, at *Polladras Downs* (*o*), a series of elevations, successively increasing as we go westward, will afford that superficial explanation which we have already seen (G[1]) is contradicted by a more minute investigation. A similar succession of movements will also apply to the *Old lode* at *Poldory (United Mines)* (*i m*), and a like explanation will apply to *Wheal Falmouth*.

At *Cook's-kitchen* (*c*), a system of elevations augmenting as they are followed eastward will produce the same apparent coincidences; and similar ones are also found in *Wheal Jewel*, *Wheal Friendship*, and in the *heaves* of the *south lode* at *Cardrew Downs* (*e*, B[2]).

But, when the *heaves* by successive *cross-veins* are in opposite directions, certain masses of rock must

[1] *Ante*, p. 368. [2] *Ante*, p. 361.

be *heaved*, and others, interposed amongst them, remain in their original positions; as, for example, at *Herland* (*n*), where this assumption requires that the portion contained between the *Halfpenny flucan* and *Chambers's western flucan* shall not have been moved; whilst, at every *cross-vein* west of the former, there shall have been, successively, an elevation more considerable as we go westward, and, at every *cross-vein* east of the latter, a similar one, still increasing in magnitude, as we go eastward.

At *Wheal Vor* (*l*), we may imagine the *heaves* by the two portions of the *eastern cross-course* to have been attended by depressions westward; but then we must require that the part between *Woolf's* and *Carleen cross-courses* shall have remained stationary, whilst the part west of the latter has also subsided. But it must still be remembered that these movements will produce only an apparent agreement, and explain only one set of phenomena: for when we compare them with the distances of the *heaves*, the resemblance vanishes.

These movements in opposite directions, and stationary masses interposed between others which have suffered contradictory motions, certainly require a liberal indulgence of imagination.

But, whether the two *cross-veins* be wholly separate and distinct ones, or whether they may be *branches* of the same which unite and form one vein at other places, the physical necessity that their *heaves* of the same *lode* must be in opposite directions will still exist, provided the only mass of rock

moved is that contained between them: for theory makes the extent of the *heaves* dependent on the inclination of the *lode* and the distance of the motion, as we have already so often seen.[1]

Now the spaces at present occupied by the *cross-reins* are supposed to have been fissures originating in the movements which produced the *heaves* of *lodes*, although their ingredients may have been introduced at a subsequent period.

At *Wheal Union* (*k*), we have every particular necessary to determine whether the same degree and direction of motion will produce fissures of the same width as the *branches* of the *cross-vein*, and, at the same time, *heave* the *lode* to the extent, and in the directions, observed at the different levels.

At 22 fathoms deep, the *trawn heaves Wheal Gwens lode* 36 feet; and, at 30 fathoms, 25 feet: but below this level it divides into three veins, of which one *heaves* the *lode* 1·5 foot; the second, 8 feet; and the third, 24 feet: in all cases towards the right hand. At the upper edge of the wedge-shaped mass of rock included between the eastern and middle branches of the *trawn*, the former of them is 6 inches and the latter 3 feet wide.

Now, in order to the production of fissures of these respective dimensions by the subsidence of this included mass of rock, in a direction, *o p*, *Pl. XII.*, *Fig.* 14, parallel to a line uniting its present vertex with the point of the cavity, at *o*, which it must, on this assumption, be presumed to have ori-

[1] *Ante*, pp. 347-360.

ginally filled, the extent of the subsidence must have been about 3·75 feet.

Again, in order that a subsidence of this wedge-shaped portion, to that extent, should produce at 43 fathoms deep the observed *heave* of 1·5 foot in the *lode* by the eastern branch of the *trawn*, the direction of the fall must be in a line which dips northward about 72° from the horizon.

But this amount and direction of motion, instead of the observed results of 25 and 36 feet respectively at 30 and 22 fathoms deep, will only produce *heaves* of 1·5 foot and 1·3 foot.

But, if the direction and extent of the motion be the same in all cases, the mechanical effects will be the same whatever is the width of the *cross-vein*, or whether it consists of a single vein, or of several.

Let us, then, assume a movement in the direction already named, dipping northward 72°, but of a sufficient magnitude to produce a *heave* of 36 feet at 22 fathoms deep: the extent of such a motion must be about 17·5 fathoms, and the following is a comparison of the calculation from such data with the facts observed:—

Depth.	*Calculated.*	*Distance of heave.*	*Observed.*
22 fms.	36 feet.	.. ..	36·0 feet.
30 „	40 „	.....	25·0 „
43 „	47 „	.....	33·5 „

But theory requires that the branches of the western *trawn* shall be attended by motions successively of greater magnitude as we go westward. But, as the two western branches have a westerly

dip, any subsidence of the mass *(horse)* of granite between them must close and obliterate any openings or fissures with a very much smaller extent of motion than is requisite for the production of the *heaves*. These theoretical demands are in direct contradiction to each other; and are also inconsistent with the prevailing opinions,[1]—that the movements which caused the *heaves* were contemporaneous with the origin of the fissures now occupied by the *cross-veins*.

At 140 fathoms deep, in *Wheal Vor*, the *eastern cross-course* divides into two veins, which diverge as they descend: the *lode* passes through the wedge-shaped piece of rock included between them, and is *heaved* by both of them towards the left hand. The fracture here theoretically assumed would have permitted this included portion to have subsided. Now, at the point of divergence, at 140 fathoms deep, the eastern branch of the *cross-course* is 6 inches, and the western 3 feet, in breadth; and the extent which the wedge-shaped mass must have subsided from the position it filled before the fracture, in order that it might leave a vacuity of the requisite dimensions, would be about 13·5 feet.

In order that a motion of 13·5 feet in extent should produce a *heave* of the observed distance of 9 feet at 150 fathoms deep, the direction of the movement should be on a line dipping southward about 57° from the horizon. The following is a comparison of the respective distances of the *heaves*, which,

[1] Mr. De la Beche, Report, p. 397.

according to computation will be produced by a movement of this extent and direction, with the *heaves* observed :—

Depth.	*Extent of heave.* Calculated	Observed.
150 fms.	9 feet.	9 feet.
170 ,, ...	10 ,, ...	5 ,,
180 ,, ...	9 ,, ...	7 ,,

Again, the following shows the distance of the movement necessary to occasion the *heaves* observed at the different points :—

Depth.	*Heaves observed.*	*Extent of motion required.*
150 fms.	9 feet.	13·5 feet.
170 ,, ...	5 ,, ...	8·0 ,,
180 ,, ...	7 ,, ...	10·5 ,,

Trifling as the actual differences are, their proportion to the total amount of the *heaves* gives them an importance they would not have otherwise possessed.

Here, too, the hypothesis which requires the subsidence of the portions of rock included between the branches of the *cross-course*, and also of that between this *cross-course* and *Woolf's*, encounters the same incompatible conditions, which require for the production of the observed *heaves* such an extent of motion as would have quite obliterated every trace of the *cross-course*, and even closed every fissure which other causes might have produced in the same position.

IV. *The configuration of the parts of the same lodes in contact with opposite sides of cross-veins.*—

The impossibility, with very few exceptions, of restoring the continuity of the *lodes heaved* by the

same *cross-vein*, by any one single motion of equal extent in all the cases, naturally leads us to examine the configuration of the portions of the same *lode* on opposite sides of the *cross-vein*, that we may ascertain whether they present such a similarity of outline as may furnish an argument in this enquiry.

For, had they been originally connected and continuous, and subsequently separated by a transverse fracture accompanied by an elevation or depression of one of the severed portions, on delineating the line of dip of both portions where they are in contact with the *cross-vein*, we should expect to find that they had a perfectly or nearly similar outline; although the direction of any movement they had undergone might not allow the corresponding parts to be found at the same levels.

The tables, I.—XCVIII., contain sufficient details of the inclinations of all the veins described to furnish us with a close approximation to their true dips. Now, if the underlie of a *lode* were delineated, and, at successive levels, the observed distances of the *heaves* were marked, and these fixed points were united with each other by lines, the two lines (of inclination) thus obtained ought to present an uniformity of contour: and the parts corresponding in figure should be found at the same or at different levels, according to the direction of the motion which had affected one or the other portion.

Pl. XII., Fig. 15, 16, 17, 18, 19, 20, present these comparisons; and it will be difficult, if not impossible, to imagine that lines so utterly dissimilar could

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ever have been united and continuous at all parts of their descent, and fractured after they had become perfectly hardened.

V. *The evidence of the relative ages of veins deduced from their intersections.*—

It has long[1] been strenuously maintained, that when one vein intersects another, the vein intersected is older than that which intersects it: but the district under consideration affords so many exceptions to the generality of this law, that, in Cornwall at least, it must be received with some limitation.[2]

Whilst the mineral composition of the containing rocks remains the same, the general character of any given vein, whether it be a *lode* or a *cross-vein*, is usually so uniform, that there can be but little doubt that similar portions of the same vein are of the same ages, although they may be situate at some distance from each other, either horizontally or vertically.

(1.) At *Ting Tang*[3] and *Wheal Friendship*[3], strings of vitreous copper ore and copper pyrites pass through the *cross-veins* and connect together the same ores existing in the *lode* on either side; and, at *East Wheal Rose*,[4] lead ore is found under circumstances precisely similar.

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[1] Dr. Borlase, Nat. Hist. of Cornwall (2nd edit., 1758), p. 152: Mr. Pryce, Mineral Cornub. (1778), pp. 82-101: M. Werner, Theory of Mineral Veins (1791), p. 51: Mr. Thomas, Report (1819), p. 21: Mr. Carne, Cornwall Geo. Trans. (1819), ii. p. 123: Mr. Hawkins, ibid, p. 227: Prof. Phillips, *Geology*, Cab. Cyclop. (1839, No. cxi.), ii. p. 136: Mr. De la Beche, Report (1839), p. 353.

[2] "I think it can be shown, that the mere fact of intersection, ought not "apart from other considerations, to be taken as evidence of the relative ages "of veins." Mr. R. W. Fox, *Report Royal Cornwall Pol. Soc.* (1836), p. 42.

[3] *Ante*, p. 270. [4] *Ante*, p. 268.

(2.) At the *Consolidated Mines*,[1] two quartz rocks, which fitted exactly into each other, were found at the two ends of a *lode heaved* by a *flucan*. The *flucan*, in the intermediate distance of 7 feet, presented a horizontal open space perfectly corresponding with the contour of the rocks in the ends of the *lode*.

(3.) At *Fowey Consols* (*q*), *Tincroft* (*r*), and *Duffield* (*p*), the *cross-veins* which *heave* some of the *lodes* are themselves *heaved* by other *lodes* exactly similar in composition; and, in short, possess all the characters common to the *lodes* which are *heaved*.

(3-*a*.) At *Polgooth* (*ff*), two *lodes* are *heaved* by one *elvan-course*, whilst one of the same *lodes* intersects another *elvan-course* in every respect similar to that by which it is itself intersected.

(3-*b*.) At *Wheal Bellon*, one of the tin *lodes heaves* two others, but is itself also *heaved* by another tin *lode*. The ingredients of all four *lodes* are exactly alike.

(4.) At *Great Work* (*y*), *Tincroft* (*r*), the *Morvah and Zennor Mines* (*x*), *West Pink* (*w*), and *Dolcoath* (*s*), the veins which are intersected at some levels, at other levels intersect the very same veins by which they had been traversed.

In the foregoing examination of the general facts we have seen that every attempt has failed to restore the continuity of any series of veins traversed by the same *cross-veins*; since any one motion, uniform in direction and extent, will be followed by greater

[1] My own Paper, Cornwall Geo. Trans., iii. p. 329.

discordances in the relative positions of the portions on opposite sides, than those which at present subsist. The parts, also, in contact with the opposite sides of the *cross-veins* have scarcely the faintest resemblance in contour to each other;—whether the comparison be made at the same or at different levels.

It has also been shown that many *heaves* are occasioned by *cross-veins* which first appear at considerable depths below the surface (*bb*); others by *cross-veins* which dwindle as they descend, and ultimately die away (*cc*); and that some of the *cross-veins* seem peculiar, or confined to certain *lodes*, and do not extend to parallel ones, however near (*dd*); whilst others appear only at certain levels on a single *lode*, and disappear upwards, downwards, and at either end (*ee*).

It has also been observed that there are breaks in the continuity of some *lodes*, which are re-discovered either towards the right or left hand, although neither *cross-vein* nor joint of the rock intervenes (*gg*).

The utter impossibility of re-producing continuity in all the *lodes* supposed to have been *heaved* by any one motion, uniform both in direction and extent, at all spots on the same *cross-vein*, seems to show, decisively, that the *heaves* can never have originated in movement of that simple and general character: even making the utmost allowance for minor fractures and modifications by other local causes.

On the other hand, the existence of *heaves* where so many conditions conclusively prove the physical

impossibility of any general motion,—the result of a great transverse fracture of the strata and veins, demonstrates that no such great and general disturbance is necessary and indispensable to their production.

We must also admit that in some cases[1] the *cross-veins* are, at least, as old as the ores contained in the *lodes* they intersect; and that, in one example (2), a movement has taken place since the materials of the *cross-vein* have occupied their present positions. In some instances,[2] too, the ingredients of the *cross-veins* and of the adjoining rocks perfectly correspond, both in mineral composition and mechanical structure.

But the prevailing opinion, that the vein intersected must be older than that which traverses it,[3] if still maintained, must be received with considerable limitation:[4] for it not only ascribes different ages to neighbouring veins which are exactly alike in every respect, on no other evidence than that of their intersections (p, q, r,); but, whenever two veins mutually intersect each other at different levels (r, s, w, x, y,), this theory places its supporters in the dilemma of requiring, that one is at the same time both older and newer than the other.

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[1] *Ante*, p. 270. [2] *Ante*, p. 263.

[3] Dr. Borlase, Nat. Hist. of Cornwall (2nd edit., 1758), p. 152: Mr. Pryce, Mineralogia Cornub. (1778), p. 101: M. Werner, Treatise on Mineral Veins (1791), p. 53: Mr. Thomas, Report (1819), p. 21: Mr. Carne, Cornwall Geo. Trans. (1819), ii. p. 123: Mr. Hawkins, ibid, p. 232: Mr. De la Beche, Report (1839), p. 353: Prof. Phillips, Cab. Cyclo., *Geology* (No. cxi., 1839), ii. p. 136.

[4] Dr. Boase, Primary Geology, p. 365: Mr. R. W. Fox, Report of Royal Cornwall Polytech. Society (1836), p. 120.

In the pursuit, therefore, of the severed portions of *lodes* which have been *heaved*, observation and experience are still our only guides.

In all the foregoing investigations[1] it has been assumed that any motions have been at periods subsequent to that at which the rocks became perfectly rigid and incompressible. Indeed it would have been vain to have attempted an explanation of the observed facts, on purely mechanical principles, under any other conditions.

If we suppose it possible for the rocks to have been so broken that each *lode* was contained in a different fragment, and that these minute masses had an independent motion, in any direction and to any extent required; although such movements might, within certain limits, have afforded any desired results; yet the motions in different directions necessary to the production of the observed phenomena, in different portions, would often have required that the rocks should, in some spots, have suffered much compression, whilst large vacuities must have been left in others. Had such convulsions ever taken place, traces of them must have been conspicuous;—but, in fact, nothing of the kind has been detected,—even in a single instance.

[1] The principles of simple mechanical displacement here investigated were held by M. Schmidt. They have been examined in detail by M. Zimmermann, "Die Wiederausrichtung verworfener Gänge, Lager, und Flotze" (Leipzig, 1828);—more generally by myself, Proceedings of the Geological Society (1832), i. p. 406: Mr. Hopkins, Cambridge Phil. Trans. (1835), vi. p. 58: Mr. Burr, Mining Review (1836), No. viii. p. 236: Mr. R. W. Fox, Report of the Royal Cornwall Polytech. Soc. (1836), p. 120: myself, Edin. New Phil. Journal (1836), xxii. p. 161; and Reports of the British Assoc. (1837), p. 74: Mr. De la Beche, Report (1839), p. 298: Prof. Phillips, Cab. Cyclo. *Geology* (No. cxi., 1839), ii. p. 145.

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memoir so strictly practical, theoretical
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thetical language, I have carefully absta
ly instance in which I have departed

for few topics of geological investigation have given rise to greater differences of opinion than those respecting metalliferous deposits. Where, however, it has been necessary to differ from the Authors I have quoted, I am not aware that I have, in a single instance, been wanting in fairness or courtesy. Still, lest any should complain of any inadvertence, I here offer my apology before hand.

With the exception of less than half-a-dozen examples, which I have given on the authority of others, and to all which I have affixed the names of my informants, I may claim all the observations as my own.

It may be imagined that I have overlooked many interesting subjects of enquiry; and also that I have omitted many important results which might have been recorded. Some topics have been passed over because they seemed to have no practical value, and I was unwilling, by needless details, to withdraw attention from matters of general utility; and either from the ruinous state of ancient workings, or because the labours of the miner had not reached them, the points of greatest interest were often inaccessible: whilst the thick coatings of ferruginous stalagmite, which is so frequently formed from decomposition, often concealed the sides of the *(levels)* galleries.

I must confess that, in a few instances, I have not deemed it prudent to encounter the risk of decayed ladders and ill-supported rubbish: but in many hundreds of others, I have had to regret that, after long and toilsome clambering over fallen rocks and

timber, and creeping through small o
ll of slime and water, my further prog
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APPENDIX.

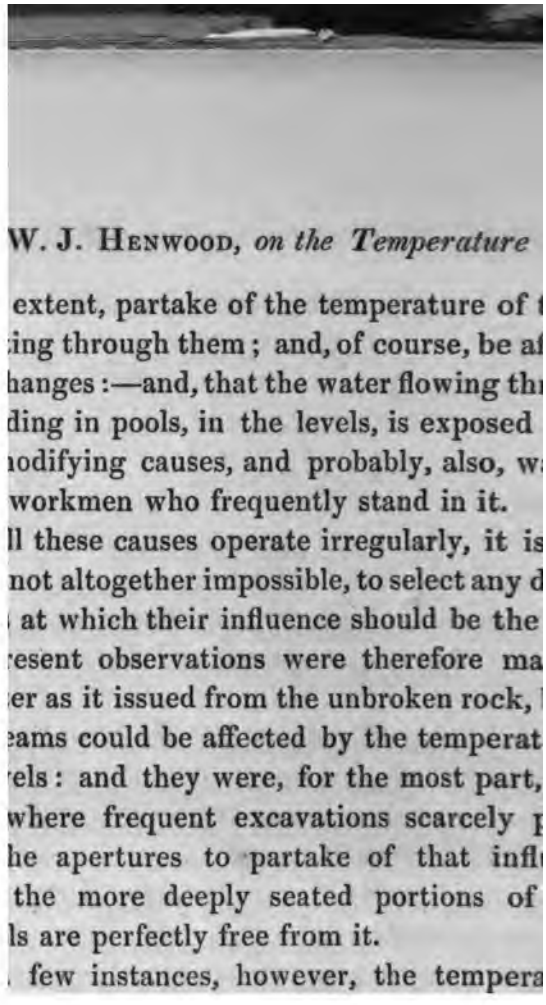
No. 1.

Observations on Subterranean Temperature in the Mines of Cornwall and Devon.

My Geological Survey of the Mines in the Duchy of Cornwall afforded many opportunities for observations on subterranean temperature, of which I always availed myself.

After most careful consideration of the subject, and consultation with others who have also been engaged in this enquiry, it has been thought best to confine the observations, as much as possible, to the temperature of the streams of water immediately issuing from the unbroken portions of the rocks and veins.

The reasons for this preference are:—that the temperature of the *air* in mines is affected, not only by the presence of the workmen, the combustion of candles, and the explosion of gunpowder, but also by the warm or cold air which is brought to the same spot by the varying directions of the currents underground, which are more or less influenced by the changes of wind at the surface:—that the *rocks*, forming the sides of the shafts and levels, must, to a



extent, partake of the temperature of t
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workmen who frequently stand in it.
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not altogether impossible, to select any d
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esent observations were therefore ma
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eams could be affected by the temperat
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where frequent excavations scarcely p
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the more deeply seated portions of
ls are perfectly free from it.
few instances, however, the tempera

TABLE No. 1.

THE SAINT JUST DISTRICT.[1]

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Wheal Cunning (Granite).		
Small,[2] out of *lode*, end[3]	70·	56°·0
„ „ bottom	90·	59°·0
Drawn to adit by engine from	80·	51°·0*
Little Bounds (Granite).		
Small, out of *lode*, end	10·	49°·5
„ pool collected in the adit	„	52°·0
Wheal Edward (Granite).		
Small, pool collected from droppings	65·	53°·0
„ „ „	75·	59°·0
Park-noweth (Granite).		
Small, out of *lode*	21·	50°·0
„ „	44·	51°·0
„ „	54·	51°·0
„ „	61·	57°·0
Drawn to adit by the engine	„	52°·75*
Botallack (Slate).		
Small, out of *lode*	44.	51°·0
„ „ end, W.	69·	54°·0
„ out of rock, N. of *lode*	99·	61°·0
Drawn to adit by engine *(Narrow)* from	„	56°·0*
„ „ *(Crowns)* „	145·	59°·0
Wheal Cock (Slate).		
Small, out of *lode*, very salt	120·	59°·0
Drawn to adit by engine from	„	52°·0*
Levant (Slate).		
Small, out of *lode*, E.	24·	51°·0
„ „ E.	138·	66°·0
„ „ W.	„	67°·0
Drawn to adit by engine from	„	61°·0*
Boscaswell Downs (Granite).		
Collected in adit	26·	49°·0
Small, out of *lode*, end, W.	116·	59°·0
„ collected in level	156·	61°·0
Drawn to adit by engine from	„	51°·0*

* The observations thus marked are not included in the averages given in Tables ii., iii., iv., and v.

1 Observations on the temperature of *Botallack*, *Little Bounds*, and *Levant*, by Dr. Forbes, Dr. Davy, Dr. Barham, and Mr. R. W. Fox, are described, Corn. Geo. Trans, ii. pp. 175, 178; ibid, iii. p. 151; Edin. Journal of Science, iii. p. 75; Report of British Assoc., vi. p. 134.

2 The first word in each line denotes the dimensions of the stream; all the others (3) describe the locality.

SAINT JUST DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.
South Wheal Rose (Granite).	
t of *lode*, end, E.	13·
,, ,, ...	,,
,, ,, ...	31·
,, ,, ...	53·
adit by engine from	35·
THE SAINT IVES DISTRICT.[1]	
Morvah and Zennor Mines (Granite).	
t of *lode*, end, E.	28·
,, ,, W.	,,
t of *trawn*	,,
,, ...	40·
t of *lode*	50·
adit by engine from	60·
Ding Dong (Granite).	
in bottom of shaft	79·
Trevidgia (Granite).	
in level from oozing out of *lode*	52·
adit by engine from	,,
Rosewall Hill (Granite).	
t of *lode*, W.	25·

SAINT IVES DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Wheal Reeth (Granite).		
Small, out of *lode*, W.	27·	53°·0
Water, a hole 6 ins. deep in Rock, N. *wall*	197·	65°·0
„ collected in bottom of shaft	207·	68°·5
Small, from back *lode*, W.	„	70°·0
Water, a hole in rock, N. *wall*, W.	227·	73°·0
„ collected in bottom of shaft	237·	69°·5
Small, out of *lode*, end, E.	„	71°·5
„ „ „ W.	„	75°·0
„ out of rock „ „	247·	76°·0
Drawn to adit by engine from	207·	56°·0*
Wheal Mary (Granite).		
Small, out of *lode*, E.	10·	53°·0
„ „ W.	21·	52°·0
„ „ E.	51·	57°·0
Very small, out of rock, S. *wall*	71·	58°·25
Drawn to adit by engine from	91·	56°·75*
Lelant Consols (Granite).		
Small, out of rock, N. *wall*	33·	55°·0
„ „ *lode*, E.	80·	60°·5
Reeth Consols (Granite).		
Small, out of *lode*, W.	98·	63°·75
Moderate, „ E.	111·	68°·75
West Poldice (Slate).		
Small, out of *lode*, back, E.	44·	60°·0
„ „ rock, N. *wall*	„	57°·0
Large, „ *lode*, back, E.	64·	62°·0
Very large indeed, out of rock, N. *wall*	73·	63°·5
Halsetown, a well in granite at the surface	—	47°·0*
THE MARAZION DISTRICT.[1]		
Wheal Elizabeth (Slate).		
Small, out of *lode*, end, W.	4·	54°·5
„ „ *flucan*	24·	55°·0
West Godolphin (Slate).		
Small, out of *lode*, end, E.	27·	58°·5
Wheal Bolton (Slate).		
Small, out of *north lode*, back, E.	23·	57°·0
„ „ *middle lode* „	65·	63°·0
„ „ rock, S. *wall*	„	63°·0
„ „ *south lode*, back	„	61°·0
Large, „ *caunter lode*	77.	64°·0
„ „ *south lode*, E.	„	64°·0
„ „ rock, S. *wall*	„	63°·0

1 The temperature in *Wheal Neptune* was observed by Dr. Forbes, Corn. Geo. Trans., ii. p. 172.

MARAZION DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.
Rospeath **(Slate).**	
e, out of *lode*, E.	52·
,, W.	,,
adit by engine from	,,
Great Wheal Fortune **(Slate).**	
t of *lode*	134·
,, rock, N. *wall*	,,
,, ,, S. ,,	,,
,, *lode*	144·
,, rock, both *walls*	,,
Gwallon **(Slate).**	
t of *lode*, back, W.	45·
,, E.	,,
,, ,,	55·
adit by engine from	,,
Wheal Darlington **(Slate).**	
t of rock	45·
,, *north lode*	,,
,, ,, both sides	50·
,, rock, 4 fms. S. of *lode*	,,
,, ,, 9 ,, ,,	,,
,, ,, 11 ,, ,,	,,
14	

THE GWINEAR DISTRICT.[1]

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Wheal Kayle (Slate).		
Small, out of *lode*, two spots in bottom	34·	59°·5
Herland (Slate).		
Very large, out of *Silver cross-course*	152·	77°·0
Small, „ *Manor* „	„	81°·0
Drawn to adit by *(Fancy)* engine from	„	66°·0*
Wheal Alfred (Slate).		
Mud in bottom of level from which water had just been drawn	155.	64°·0
	„	65°·0
Carzise Consols (Slate).		
Large, out of rock, N. *wall*	75·	68°·0
„ „ *lode*, end, E.	85·	66°·0
Drawn to adit by engine from	„	63°·0*
Binner Downs (Slate).		
Small, out of *north lode*, back	50·	56°·5
„ „ „	96·	65°·5
„ „ *south lode*, „	126·	67°·0
„ „ rock, N. *wall*, two streams	136·	65°·0
Moderate, out of *north branch*, end, W.	156·	74°·5
„ „ *south lode*, „ E.	166·	76°·0
„ „ *north branch* „ W.	176·	82°·0
Large, jetting out of *south lode*, „ E.	186·	82°·5
„ out of „ bottom	„	83°·0
Very large indeed, jetting out of *south lode*, end, W.	„	86°·5
Wheal Strawberry (Julia) (Slate).		
Small, out of *lode*, end, W.	70·	60°·0
„ „ „ E.	„	60°·0
„ „ „ „ „	79·	61°·5
Duffield (Weeth) (Slate).		
Moderate, out of *lode*, S. part	98·	63°·0
„ „ N. „	„	64°·5
Drawn to adit by engine from	„	61°·2*
Godolphin (Slate).		
Small, out of *lode*, back	20·	53°·0
„ „ *Orchard lode*, end, W.	30·	59°·0
„ „ *Pearce's lode* „ „	50·	58°·0
„ „ rock, near *Pearce's lode*	„	58°·0
„ „ *Pearce's lode*, end, W.	70·	65°·0
„ „ bottom of *Pearce's shaft*	80·	66°·0
„ „ *Sims's lode*, end, W.	„	64°·0
„ „ „ „ E.	90·	66°·0
„ „ „ „ W.	„	68°·0
Large, „ „ bottom of shaft	92·	70°·0
Drawn to surface by engine from	„	67°·0*

1 Observations on the temperature of *Wheal Abraham, Crenver, Oatfield, Trenoweth, Wheal Alfred, Herland,* and *Relistian* are detailed by Mr. Thomas Lean, Mr. R. W. Fox, Dr. Forbes, and Mr. M. P. Moyle; Phil. Mag., xlii. p. 204; Cornwall Geo. Trans., ii. pp. 14-191-407-408-410-411-412; ibid. iii. pp. 317-323.

THE HELSTON DISTRICT.[1]

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Great Work (Granite).		
Small, from *Wheal Breage lode*, back	96·	62°·5
„ „ end, W.	132·	64°·0
„ „ „	142·	64°·5
„ „ *Great Work lode*, back	„	64°·5
Polladras Downs (Slate).		
Small, from *Bor lode*, end, E.	73·	61°·0
„ „ *Bisn lode*, „	83·	64°·0
„ „ *Bor lode*, end, W.	93·	63°·5
Large, „ „ E.	103·	66°·0
„ „ „ „	113·	64°·5
Well at surface, between Trew and *Wheal Vor* (in slate),		
1838, June 13th	—	51°·0*
„ July 18th	—	48°·0*
Wheal Vor,—		
Carleen (Granite).		
Small, out of *lode*, end, W.	28·	52°·0
„ „ „ E.	128·	66°·0
„ „ „	138·	68°·0
„ „ „	148·	69°·0
Drawn to adit by engine from	„	59°·0*
Eastern part (Slate).		
Small, out of *lode*, back	190·	68°·5
Large, „ E.	230·	78°·0
„ „ „	240·	81°·0
„ out of a hole between *lode* and rock, E.	„	80°·5
Drawn to adit by engines from	„	69°·0*
Wheal Trewavas (Granite).		
Small, out of *Way Sowan lode*	43·	61°·0
Large, „ rock near *lode*	„	61°·0
„ „ *south lode*, end, E. (salt)	60·	57°·0
Drawn to adit by engine from	„	56°·0*
Wheal Trannack (Granite).		
Moderate, out of *lode*, end, W.	74·	64°·5
Wheal Trumpet (Granite).		
Small, oozing from *lode*	128·	65°·0[2]
„ out of *lode*, back, W.	148·	68°·5
Wheal Ann (Granite).		
Small, out of *lode*, E.	12·	52°·5
„ jetting out of *lode*, E.	142·	67°·0
Drawn to adit by engine from	„	59°·0*

1 On the temperatnre of *Wheal Vor*, *Wheal Trumpet*, *Trevenen*, and *Wheal Rose*, observations by Dr. Forbes, Mr. M. P. Moyle, Dr. Barham, and Mr. R. W. Fox, appear in the Corn. Geo. Trans., ii. pp. 185-406-411; ibid, iii. pp. 151-318; Phil. Trans. (1830), p. 407.

2 This observation made by me was first published by Mr. R. W. Fox, Corn. Geo. Trans., iii. p. 318.

THE CAMBORNE DISTRICT.[1]

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Stray Park (Slate).		
Small, out of *lode*, back of end, W.	188·	73°·5
Dolcoath (Slate).		
Small, out of rock	17·	54°·0
Cook's-kitchen (Granite).		
Drawn to adit by engine from	131·	60°·75*
There is water 65 fathoms deep in the bottom of the mine.		
Tincroft (Granite and Slate).		
Large, out of *cross-course*, S. (granite)	26·	52°·2
Small, collected in bottom of level, *Highburrow lode* (slate) ..	166·	65°·0
South Roskear (Slate).		
Moderate, jetting out of *lode*	117·	62°·0
Small, „	129·	68°·0
„ out of *lode*	139·	71°·0
Drawn to adit by engine from	„	63°·0*
North Roskear (Slate).		
Small, out of *lode*, back	67·	61°·0
„ jetting out of *lode*, end, E.	107·	66°·0
„ out of *lode*, „	137·	73°·0
„ „ end, W.	„	70°·0
Drawn to adit by *Wheal Crofty* engine from	76·	61°·0*
East Wheal Crofty (Slate).		
Small, out of *Trevenson lode*	80·	61°·0
„ „ rock, 20 fms. N. of *lode*	„	62°·0
„ „ *Cherry Garden lode*, back	„	63°·75
„ „ „ end, W.	„	62°·0
„ „ *Longclose engine lode*	85·	63°·5
„ „ „ water in a hole in *lode*,	„	64°·25
„ „ „ back of level ..	„	66°·0
„ „ „ end	„	60°·0
This observation was made two years after the three preceding it and after the mine had been sunk 30 fathoms deeper.		
Small, out of *Fane's lode*, end	86·	57°·0
„ „ *Reeve's lode*, ...	110·	68°·5
„ „ „	115·	69°·0
„ „ „ two years after the preceding, the mine having in the interval been sunk 30 fms. deeper ..	„	62°·0
Small, out of rock, W.	126·	66°·5
„ „ N. *wall*	135·	70°·75
Drawn to adit by engine from	150·	58°·5*
East Pool (Slate).		
Large, out of *lode*, back, E.	62·	59°·0
„ „ *cross-course*, near the *lode*	„	58°·5

1 The temperatures in *Stray Park*, *Dolcoath*, *Cook's-kitchen*, *Tincroft*, and *Wheal Wellington* have been observed by Mr. R. W. Fox and Dr. Forbes, Corn. Geo. Trans., ii. pp, 14-20-189; ibid, iii. 318.

CAMBORNE DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Cairn Brea Mines (Granite).		
Large, out of *lode*, end, E.	131·	60°·75
,, ,, rock, near *lode*	,,	61°·75
Very large, jetting out of *cross-course*	151·	63°·0
Drawn to adit by engine from	,,	63°·5*
Bisleak-well (in granite), at surface, about 420 ft. above the sea	—	52°·0*
Camborne-beacon (granite), ,, ,, 520 ,, ,,	—	49°·0*
Cairn-Brea-well (in granite), near the Castle, about 680 feet above the sea	—	48°·0*
THE REDRUTH DISTRICT.[1]		
Wheal Uny (Slate).		
Large, out of *lode*, W.	65·	58°·3
Very large, ,, E.	72·	59°·0
Large, out of rock, S.	,,	60°·0
Small ,, *lode*, back	81·	61°·5
Wheal Buller (Slate).		
Small, out of rock, two spots	29·	52°·8
,, ,, ,, ,,	,,	52°·8
,, ,, *cross-course*	,,	52°·8
,, ,, *Wheal Beauchamp lode*	49·	54°·0
Large, ,, ,,	59·	55°·5
Small, ,, rock, W.	79·	59°·3
,, ,, *Davey's lode*, end, W.	89·	60°·5
,, ,, ,, 6 feet from end	,,	59°·5
,, ,, rock *(elvan)*	99·	61°·0
Drawn to adit by *Wheal Buller* engine from	,,	59°·0*
,, *Wheal Beauchamp* engine from	,,	58°·0*
Tresavean (Granite).		
Small, out of *lode*, end, E.	240·	78°·0
,, ,, ,,	252·	79°·75
,, ,, issuing very irregularly	264·	83°·0
,, ,, end, E.	,,	85°·0
,, out of rock, N. *wall*	,,	84°·5
Air, in bottom of a *winze*	,,	86°·0*
Wheal Vyvyan (Granite).		
Small, out of rock	22·	52°·0
,, ,, *lode*	77·	55°·5
Drawn by engine from	32·	51°·0
,,	42·	52°·6
,,	52·	52°·6
,,	62·	54°·6
,,	77·	55°·0

1 In the Corn. Geo. Trans., ii. pp. 14-20-405; ibid, iii. pp. 314-315-317; Phil. Trans. (1830), p. 407; and Reports of the British Association, vi. pp. 135-137, will be found observations by Mr. R. W. Fox, Mr. M. P. Moyle, and myself, on the temperatures of *Treskerby*, *Chacewater*, *Wheal Gorland*, *Wheal Unity Wood*, *Creegbraws*, *Wheal Unity*, *Poldice*, the *United* and *Consolidated Mines*, *Ting Tang*, *Wheal Squire*, *Tresavean*, *Wheal Damsel*, and of the water discharged by the great adit into Carnon Valley.

REDRUTH DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Pennance (Slate).		
Drawn to surface by engine from	20·	56°·0*
Cardrew Downs (Slate).		
Moderate, out of *lode*, end	120·	64°·5
Chacewater Mine (Slate).		
Large, out of *lode*, end, E.	128·	75°·01
Small, „ „ W.	„	68°·0[1]
„ „ rock	„	72°·0
Poldice (Slate).		
Small, out of *lode*, end, W.	184·	100°·02
„ „ „ E.	„	99°·0[2]
Wheal Jewel (Granite).		
Small, out of *lode*, end, W.	90·	64°·0
East Wheal Damsel (Granite).		
Small, jetting out of *north lode*, end, W.	110·	63°·0
„ out of *north lode*, „	150·	71°·5
„ „ *south lode*, „ E.	„	68°·0
Drawn to adit by engine from	180·	64°·0*
Consolidated Mines (Slate),—		
(Western district, West Wheal Virgin).		
Air, at end of level (Monday Morning)	204·	86°·0*
Moderate, out of *Taylor's lode*, end, W.	284·	89°·0
„ „ back, E.	„	89°·5
Large, „ end, E.	294·	93°·5
„ „ „ W.	„	92°·5
Air, at end, E., on *Taylor's lode*	„	96°·0*
„ W., „	„	94°·0*
Moderate, out of *south branch*, bottom	„	95°·5
„ „ back	„	93°·5
Water collected at bottom of *Davey's* engine-shaft	„	92°·5°3
(Middle district, East Wheal Virgin).		
Air, at end, E. *Wheal Fortune lode*	250·	87°·0*
Large, out of „ end, E.	„	86°·5
„ „ *Deeble's branch*	287·	94°·0
„ „ rock, between *Deeble's branch* & *Wh. Fortune lode*	„	94°·5
„ „ *Wheal Fortune lode*	„	93°·0
Air, at end of level, W.	„	94°·0*
Small, out of vein, S. of *Wheal Fortune lode*	„	92°·0
„ „ hole in rock, near the *lode*	„	91°·0
„ „ „ 20 fms. S. of *lode*	„	92°·0
Water collected at bottom of *Pearce's* engine shaft	„	91°·0°3
„ drawn to adit by *Pearce's* engine from	„	77°·5*

1 These observations made by me were published by Mr. R. W. Fox, Corn. Geo. Trans., iii. p. 317.

2 These observations made by me were published by Mr. R. W. Fox, Phil. Trans. (1830), p. 408.

3 In this water the labourers at the bottom of the mine plunge to *cool* themselves.

REDRUTH DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.
(Wheal Fortune).	
d of level	185·
, out of *lode*, back of end, E.	195·
ting out of *lode*, end, W.	205·
e, ,, ,, ...	215·
,, back	,,
d of level, 5 fms. from shaft	,,
(Cusvey).	
t of *lode*, end, E.	153·
,, back of end, W.	173·
United Mines (Slate),—	
(Eastern part, Ale and Cakes).	
e, out of *Great south lode*	170·
,, a hole 8 ins. deep in rock	,,
,, *Great south lode*, N. part	180·
,, ,, S. ,, ...	,,
ge ,, *cross-course*	,,
,, rock, 2 feet from last obs.	,,
, ,, *Great south lode*, S. part	195·
,, rock, close to *lode*	,,
,, ,, between *Gt. south lode* and *Old lode*,	,,
,, *Old lode*, end, W.	,,

REDRUTH DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Temperature of the water discharged into Carnon Valley by the great adit of the Gwennap mining district: and of a well, and the river near its mouth.*—		
1839 River.[1] 51°·0 · Ferney Splat, well, surface, 4ft. from adit. 53°·0 · Great adit.[2] 63°·4 · Nangiles adit. 61°·5		
Jan. 2, .. 51°·0 .. 53°·0 .. 63°·4 .. 61°·5		
March 8, .. 48°·5 .. 50°·3 .. 63°·2 .. 60°·0		
July 16, .. 71°·75 .. — .. 66°·5 .. —		
1840		
Jan. 1, .. 52°·0 .. 52°·25 .. 60°·5 .. 59°·25		
27, .. 48°·0 .. 51°·5 .. 60°·5 .. 60°·0		
March 9, .. 57°·0 .. — .. 65°·0 .. 61°·0		
31, .. 73°·5 .. — .. 66°·5 .. 62°·75		
April 16, .. 64°·0 .. — .. 68°·0 .. 59°·75		
1842		
Dec. 30, .. 53°·5 .. 53°·0 .. 64°·5 .. 61°·0		
THE SAINT AGNES DISTRICT.[3]		
Wheal Towan (Slate).		
Moderate, out of *lode*	108·	62°·0
Collected from 73 fms. to	124·	67°·5
Small, out of *lode* (a gurgling noise, as of air escaping, occurs in this stream)	134·	69°·5
„ „ end, E.	„	72°·5
„ out of rock, back of end, W	„	70°·0
„ „ *lode*, end, W.	144·	70°·0
„ jetting out of *lode*, end, E.	„	74°·75
„ „ „ W.	154·	72°·0
„ out of *lode*, „ E.	„	72°·5
East Wheal Charlotte (Slate).		
Small, out of rock	42·	59°·0
Penwinnick (Slate).		
Large, jetting out of *lode*, end, W.	32·	57°·5
„ out of *lode*, back, W.	42·	59°·0
West Pink (Slate).		
Small, out of *lode*, end, W.	70·	60°·0
Drawn to adit by engine from	90·	61°·5*

1 On the 27th of June, at One p.m., I examined the temperature of the river immediately above the *Falls of Niagara*, and found it 68°, that of the air being 69°. At Eight p.m., the same day, the surface of the water in Lake Ontario, a mile from the shore, was at 47°·75, the air being at 67°.

2 Mr. R. W. Fox (Corn. Geo. Trans., iii. p. 316) states that in 1822 the temperature of the water discharged by this adit was 69°·25, but he has not mentioned at what period of the year the observation was made.

3 The temperature in *South Wheal Towan* has been recorded by Mr. R. W. Fox, Corn. Geo. Trans., iii. p. 314.

SAINT AGNES DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Wheal Prudence (Slate).		
Large, out of *lode*, end, W.	109·	65°·5
Wheal Leisure (Slate).		
Moderate, out of rock, S. *wall*	86·	69°·0
Small, „	96·	73°·0
Large, out of *lode*, ...	„	69°·0
Wheal Budnick (Slate).		
Moderate, out of rock, W. *wall*	64·	59°·0
„ „ E. *wall*, near end	„	60°·0
„ „ „ 10 fms. from last obs. ..	„	60°·4
„ „ „ 10 fms. from last obs. ..	„	61°·2
„ out of *Lead lode*	74·	63°·5
Drawn to adit by engine from	„	60°·0*
THE SAINT AUSTELL DISTRICT.		
Polgooth (Slate).		
Drawn to surface by engine from	32·	55°·5*
Charlestown United Mines (Slate).		
Small, out of rock, S. of *lode*	52·	55°·0
Pembroke (Slate).		
Small, out of *lode*, end, W.	120·	72°·0
Drawn to surface by engine from	„	57°·5*
East Crennis (Slate).		
Large, out of *south lode*, end, W.	102·	70°·0
Fowey Consols Mines (Slate).		
Small, out of *Crosspark lode*, back	160·	67°·0
„ „ „ end	„	68°·5
Large, „ *cross-course*, back	220·	87°·0
„ „ „ end, N.	„	90°·5
THE CALLINGTON AND TAVISTOCK DISTRICT.[1]		
Redmoor Consols Mines (Slate).		
Small, out of rock	18·	54°·0
Drawn to adit by engine from	39·	57°·0*
Wheal Franco (Slate).		
Large, out of *lode*, end, W.	60·	63°·5
Drawn to adit by engine from	„	60°·0*

1 In this district the temperatures of *Wheal Friendship*, *Beeralston*, *East Liscombe*, and *Gunnis Lake* have been recorded by Mr. R. W. Fox, Corn. Geo. Trans., iii. pp. 314-321.

CALLINGTON AND TAVISTOCK DISTRICT continued.

Name of Mine, Rock, Appearance of Stream, and Locality of observation.	Depth fms.	Temp.
Wheal Friendship (Slate).		
Moderate, out of *eastern cross-course*	47·	55°·0
Large, „ *cross-course*, two streams, both	75·	54°·0
Moderate, „ „	115·	64°·0
„ „ „ 6 ins. from last obs. ..	„	65°·5
„ „ rock, W.	„	64°·0
Large, out of *lode*	„	60°·0
„ „ 6 ins. from last obs.	„	62°·0
Small, „	135·	69°·5
Drawn to surface by engines from	„	62°·0*
Wheal Calmady (Slate).		
Moderate, out of *cross-vein*, end, S.	24·	54°·0
Drawn to surface by engine from	„	53°·5*
Well at Roborough Down, surface (slate)	—	49°·0*

The foregoing materials furnish the means of comparing the temperatures at similar depths, in the different districts;—in the different rock formations;—in the *lodes* yielding different ores;—and in the rocks, *lodes*, and *cross-veins*.

e following table presents a comparison
eratures prevailing at nearly similar dep
ifferent districts, in which the mines of
nd Devon seem naturally grouped :—

LE II.

50 fms.	150 to 200 fms.		200 fms. & beyond		Means	
Temp.	Depth fms.	Temp.	Depth fms.	Temp.	Depth fms.	Temp.
62°·75	156·	61°·01	—	—	95·	57°·84
67°·0	197·	65°·01	228·	72°·01	129·	63°·56
71°·33	—	—	—	—	76·	63°·87
66°·0	167·	76°·0	—	—	101·	63°·4
66°·1	190·	68°·5	237·	80°·01	134·	66°·66
66°·54	168·	67°·17	—	—	98·	62°·13
70°·64	177·	86°·07	245·	89°·17	132·	71°·37
69°·0	154·	72°·25	—	—	99·	65°·91
71°·0	160·	67°·75	220·	88°·751	136·	70°·62
64°·16	—	—	—	—	72·	59°·07
67°·43	173·	78°·0	240·	85°·52	112·	66°·88

TABLE III.

Mean temperatures at nearly equal depths in the granite and slate rocks.

Depths.	Granite.		Slate.	
	Depth fms.	Temp.	Depth fms.	Temp.
Surface to 50 fms.	25·	52°·67	30·	55°·9
50 to 100 fms.	71·	57°·68	73·	61°·9
100 „ 150 „	132·	65°·0	125·	68°·14
150 „ 200 „	161·	65°·71	174·	79°·17
200 fms. and beyond	240·	76°·15	241·	89°·4
Means	94·	60°·35	116·	68°·89

1 From five observations only.

TABLE IV.

Mean temperatures of the rocks, *cross-veins*, and *lodes*, at nearly equal depths.

Depths.	Rocks.		*Cross-veins.*		*Lodes.*	
	Depth fms.	Temp.	Depth fms.	Temp.	Depth fms.	Temp.
Surface to 50 fms.	32·	55°·52	31·	53°·76	29·	54°·83
50 to 100 fms.	70·	60°·2	76·	61°·2	71·	59°·87
100 „ 150 „	134·	69°·66	115·	64°·75[1]	126·	66°·88
150 „ 200 „	180·	82°·11	163·	74°·4	161·	72°·41
200 fms. and beyond	235·	87°·9	220·	88°·75[1]	246·	88°·57
Means	111·	67°·55	99·	64°·82	111·	66°·04

1 From only two observations.

TABLE V.

Mean temperatures, at nearly equal depths, in the *lodes* which contain ores of different metals.

Depths.	Tin *lodes*.		*Lodes* yielding both tin & copper ores.		Copper *lodes*.	
	Depth fms.	Temp.	Depth fms.	Temp.	Depth fms.	Temp.
Surface to 50 fms.	27·	53°·14	33·	55°·06	32·	56°·9
50 to 100 fms.	71·	59°·15	72·	61°·16	74·	61°·8
100 „ 150 „	129·	65°·92	124·	66°·09	127·	68°·39
150 „ 200 „	181·	64°·83[1]	171·	81°·75[2]	172·	78°·33
200 fms. and beyond	230·	74°·3	—	—	244·	89°·14
Means	92·	60°·69	74·	61°·45	140·	72°·39

1 From three observations only. 2 From four observations.

The following table indicates the respective ratios of increase in temperature, expressed in fathoms of descent requisite to produce an elevation of one degree. The columns 2 and 3 are formed from Table III.; 4, 5, and 6 from Table IV.; 7, 8, and 9 from Table V.; and the last is the arithmetical mean of all the others. The eight columns are therefore deduced from the same facts, grouped in three different ways: it may therefore be anticipated that there will be considerable resemblance,—between some of them, at least.

The temperature of the air at Plymouth and Penzance, which are near the eastern and western limits of the mining districts of Devon and Cornwall, has been very accurately[3] determined: and the

[3] The mean temperature of Plymouth is stated, by Mr. Harris, at 52°·081; Reports of the British Association, vii. p. 24: that of Penzance, at 52°·0, by Mr. Giddy, Phil. Mag. and Annals, iii. p. 182.

observations made at several intermediate spots[1] may, perhaps, be equally relied on.

But this temperature, though affecting the rock to the depth of several feet,[2] cannot extend its influence very far; and, consequently, the observations made upon it will not, perhaps, avail much in the present enquiry.

No experiments have been made in Cornwall to determine at what depths, in different soils and rocks, at various periods of the year, the effects of atmospheric temperature cease, and those of subterranean heat commence.

Mr. R. W. Fox's observations[3] on the temperature at the depth of a few feet, are the only ones here with which I am acquainted: and, because in many of the wells and shallower parts of the mines which I have

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1 Observations on the temperature of Truro are recorded in the Reports of the Royal Institution of Cornwall: and of Falmouth, in the Reports of the Royal Cornwall Polytechnic Society.

2 Professor Forbes, from observations made in the neighbourhood of Edinburgh, states, on the average of three years' experiment, that the effects of atmospheric temperature will become insensible at the following depths, in different substances:—

Trap rock	55·5 feet.
Sand	65·8 „
Sandstone	96·1 „

Reports of the Brit. Assoc. (1840), p. 435.

At Paris the effects of atmospheric temperature ceased at 25 feet; whilst in various Prussian mining establishments it was found to extend to depths varying from 27 to 63 feet.

Professor Bischoff, Edin. New Phil. Journal, xxiii. (1837), p. 341.

3 The bulbs of the thermometers were sunk to a depth of three feet below the surface, and the mean annual temperatures observed were,—

At Wheal Gorland (granite)	48°·09
„ Dolcoath (slate)	49°·94
„ Falmouth (slate)	50°·67
Mean	49°·86

Mr. R. W. Fox, Corn. Geo. Trans., iii. p. 326.

ned (Table I.), I have obtained the same
iz. about 50 degrees, I concur with h
ng that we may begin our computatio
emperature; and I have, accordingly, ta
point of departure.

TABLE VI.

epths.	Granite.	Slate.	Rocks.	*Cross-veins.*	*Lodes.*	Tin *lodes.*	*Lodes* yielding both tin & copper ores.	*Copper lodes.*
	Fms.	Fms.	Fms.	Fms.	Fms.	Fms.	Fms.	Fms.
o 50 fms. ..	9·3	5·0	5·8	8·2	6·0	8·6	6·5	4·
00 fms.	9·1	7 1	8·1	6·0	8·3	7·3	6·4	8·
50 ,, ...	8·3	8·3	6·7	11·0[3]	7·8	8·5	10·5	8·
00 ,, ...	—[2]	4·4	3·7	4·9	6 3	—[4]	3·0[5]	4·
and beyond,	7·5	6·5	9·5	3·9[3]	5·2	5·1	—	6·
Means	8·5	6·2	6·7	6·8	6·7	7·3	6·6	6·

one cause of the observed irregularities in temperature: but it will presently be seen that there are others, which depend on the geological characters of the rocks and veins.

Table II. shows that the subterranean isothermal lines are not exactly parallel to the configuration of the surface; although, in many instances, there is a sort of distant resemblance in their outline.

Table I. presents many examples of different temperatures at equal depths; not only in the same mines, but even in various parts of the streams of water flowing out of the very same crevices and apertures, within a few feet, or even inches, of each other. It need, therefore, excite no surprize that there is not a perfect uniformity in the temperatures of tracts miles distant from each other.

(2.) No attempt to determine the difference between the mean temperature of the granite and slate, at various depths, was made before this enquiry had been considerably advanced;[1] although the fact had been alluded to,[2] and had been, from time immemorial, known to practical miners.[3]

This difference is exhibited in Table III., and is far more conspicuous in the deeper than in the shallower levels.

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1 My own Papers, Thomson's Records of General Science, iv.(1836), p. 198: Reports of the British Association, vi. (1837), p. 36.

2 Mr. R. W. Fox, Annals of Philosophy, iv. (1822), p. 447; Phil. Mag. and Annals, ix. (1831), p. 98.

3 "From observations carried on in various mining establishments in the "Prussian dominions, M. Von Dechen finds that the increase of temperature is, "in general, much more rapid in coal than in metalliferous mines."

PROF. BISCHOFF, *Edin. New Phil. Journal*, xxiv. (1838), p. 141.

granitic rocks may be more exposed t
influences of descending streams, as
re permits the percolation of water
than that of the slate series.

The general impression has been tha
ature of the rocks is lower than that o
the results of my enquiries, however
ly demonstrate that, at all depths, the
rmer than the *lodes*, and the *lodes* tha
eins.—(Table iv.)

well known to miners that the largest st
er flow through the *cross-veins*;[2] smalle
h the *lodes*; whilst but little issues fro
whether granitic or slaty. It is an eq
ized fact, that a considerable portion o
pumped out of our mines has been rain-w
must have entered the ground at a tem

whilst, as the rocks absorb the smallest proportion of it, they will therefore suffer the least depression of temperature.

That this is one cause of the observed difference, can admit of no doubt;—whether it is the only one, is foreign to this enquiry.

It may be true that the ascent of vapour, which would tend to raise their temperature,[1] is facilitated by the more porous nature of the veins; but, on the other hand, it must not be forgotten, that this porous structure also affords a readier passage for the descending water.

(4.) The working miners of Cornwall have long known that the *lodes* containing tin ores are, at equal depths, colder than those in which copper ores occur. This has been noticed by Mr. M. P. Moyle:[2] but no attempt has, until now, been made to determine the exact difference between them.

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in the copper *lode;* and, unless overflowed by water, it for many months indicated a temperature varying only from 75°·0 to 75°·5.

Cornwall Geo. Trans., ii. p. 27.

But, in metalliferous districts, the constancy of the temperature of water issuing from the same spot, at distant periods, must depend on the subterranean works remaining unaltered: for, if the deeper levels are untouched, and the shallower ones are extended, the warm water from below will rise as before, whilst the cold from above will be intercepted, and thus the temperature of that flowing from intermediate spots will rise. If, on the other hand, the shafts are deepened and levels *driven* beneath, whilst the shallower ones are unwrought, the former will intercept the warm water and prevent its rising, and the cold water from above still flowing as before, the temperature of intermediate stations will decline.

Such, in fact, is the case at *East Wheal Crofty*, where the temperatures at two different spots, within two years, diminished,—the one 8°·0 to 7°·25, and the other 7°·0; both parts of the mine having in the interval been deepened 30 fathoms.

Whatever cause may increase the water from above, must lower the temperature; whilst any addition to that from below, must elevate it.

[1] Mr. R. W. Fox, Corn. Geo. Trans., ii. p. 16. [2] Ibid, ii. p. 414.

e v. clearly proves the truth of this po
: and indicates that the *tin-lodes* posses
temperature,[1] and *copper-lodes* the hig
he *lodes* in which the ores of both meta
hold, in this respect, an intermediate pos
The general fact of a progressive elevati
ature as we penetrate further into the
earth, naturally leads us to enquire the
ncrease.

manner in which Table VI. is constr
en already described; and as the ratios
by the different varieties of rocks and
re exhibited connectedly and at one view
s to dilate on them.

n the surface to 150 fathoms deep, the ri
ature, for equal increments of depth, s
in a diminishing ratio:—a fact previ

number of observations I have made at more than 150 fathoms deep is very considerable.

The various ramifications of the great adit in the Gwennap mining district have an aggregate extent of between thirty and forty miles. It drains a tract of about 5,550 acres in area, and discharges nearly 1,600 cubic feet of water per minute. Rather less than one-half of this stream is collected at the adit level, whilst the remainder is pumped up from a mean depth of about 190 fathoms. Its temperature varies between 60°·5 and 68°·0, and is, on an average, more than 12° above the mean of the climate.

The subject of subterranean temperature attracted attention in France and Germany long before it did so in this country.[1] Though I have made some

[1] M. Daubuisson, des Mines de Freiberg, i. p. 258; ibid, iii. pp. 151–186–200: M. de Trebra, Annales des Mines, i. (1816), p. 377; ibid, iii. (1818, observations made 1805-7), p. 59: M. Hassenfratz, ibid, i. p. 378: M. Le Baron Cordier, Sur la Température de l'intérieur de la Terre, Memoires de l'Académie des Sciences, vii. (1827): M. J. Levallois, Annales des Mines, iii. (1833), p. 629: M. Reich, Beobachtungen ueber die Temperatur des Gesteins in verschiedenen Tiefen in den Gruben des Sachsischen Erzgebirges in den Jahren 1830 bi 1832: Prof. Bischoff, Edin. New Phil. Journal, xxiii. (1837), p. 330; ibid, xxiv. (1838), pp. 132–252.

NOTE *to page* 388, *line* 1.—"During his observations on the hourly variations "of the magnet, Reich had an opportunity of observing the rapidity with which "the air operates upon the rock even at a distance of 40 inches. The air in "the mine shewed 48°·6 with but slight variations, and a thermometer sunk "into the rock 48°·64; but when, after 44 hours' observation of the magnet, "the temperature of the air had been raised by the presence of the observers, "and their two candles, to 49°·7, the thermometer in the rock, which was subject to no change of air whatsoever, was found to have risen to 48°·71, "48°·73. This destroyed all hope of obtaining the temperature of the rock, "quite free from the influence of the air, by sinking thermometers even 40 "inches deep into the rock."

PROFESSOR BISCHOFF, *Edin. New Phil. Journal*, xxiii. (1837), p. 342.

NOTE *to page* 407, *line* 7.—"A chthonisothermal line of any temperature, "which was under a small district parallel to the surface, cannot continue its "course under a neighbouring mountain, either parallel to the external configuration of the mountain, or in the continuation of its former direction, but "must curve upwards." Ibid, xxiv. (1838), p. 146.

progress in a comparison of the results there observed with those obtained here, and such an enquiry would embrace many points of interest, I must defer its completion until a more convenient opportunity; as, in this communication, I have purposely confined myself to my own observations in Devon and Cornwall.

W. J. HENWOOD.

4, CLARENCE-STREET, PENZANCE,
1843, JANUARY 16th.

APPENDIX.

No. 2.

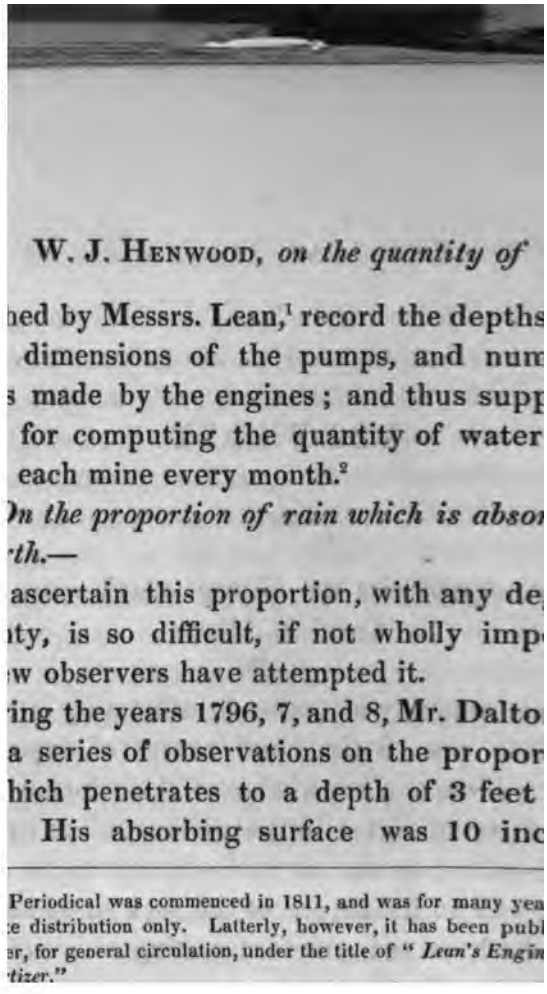
On the quantities of Water which enter the Cornish Mines.

As the quantity of water is often very great, its removal is one of the chief causes of expense in mining. Hence, a knowledge of the relation which the quantity of water in the various mines bears to the rain falling on the surface,—to the depth of the mines,—and to the nature of the rock in which they are worked, is not only interesting in a scientific point of view, but useful in an economical one.

In some mines a great increase in the quantity of water almost immediately succeeds the commencement of the heavy autumnal rains; in others, on the contrary, this increase, although it is equally certain, does not take place until after an interval of several months. The necessary inference is, that the increase, at least, is owing to the rain-water, which, absorbed by the surface, has found its way into the deeper parts of the mines.

The monthly reports of the *duty*[1] performed by the steam-engines pumping water out of the mines,

[1] The *duty* of a steam-engine is the weight lifted by it during the consumption of a given portion of fuel.



W. J. HENWOOD, *on the quantity of*

ıed by Messrs. Lean,[1] record the depths
dimensions of the pumps, and num
s made by the engines; and thus supp
for computing the quantity of water
each mine every month.[2]

)n the proportion of rain which is abso
'th.—

ascertain this proportion, with any de
ıty, is so difficult, if not wholly imp
w observers have attempted it.
ing the years 1796, 7, and 8, Mr. Dalto
a series of observations on the propor
hich penetrates to a depth of 3 feet
His absorbing surface was 10 inc

Periodical was commenced in 1811, and was for many yea
e distribution only. Latterly, however, it has been publ
r, for general circulation, under the title of "*Lean's Engin*
tizer."

diameter,[1] and for the first year it was bare, but during the two last years it was covered with grass.

The mean annual fall of rain was 33·55 inches, of which there penetrated to a depth of 3 feet, 8·41 inches. This gives the quantity of rain on an acre as 121,484 cubic feet a year; of which the absorption was 30,492 cubic feet, or an average daily absorption and re-discharge (as if from a spring) of 83 cubic feet per acre: the quantity absorbed being about a quarter part of the rain falling.

In April, 1825,[2] Mr. Thomas[3] estimated the drainage of the river Fowey at about 160 cubic feet of water per day from each acre; and, during heavy rains, at more than double that quantity. In June, 1826[4] (a very dry season), he calculated the quantity at about 75 cubic feet per day from each acre. The mean annual drainage he considers to be about 43,800 cubic feet from each acre, or 120 cubic feet per day.

Now Mr. Giddy's register of rain from 1823 to 1829,[5] both inclusive, gives a mean of 46 inches per annum, or 166,834 cubic feet per acre.

Hence, supposing all that is taken up by the earth flows out again in springs, the absorption by

[1] Mr. Dalton also attempted to determine the quantity of rain-water flowing off the surface, and between the 25th of January and 3rd of June, 1796, it was 1·41 inch; whilst that which was absorbed and penetrated to the depth of 3 feet in the earth was, during the same period, 1·6 inch.

Derangement of the apparatus interfered with the continuance of these observations. Memoirs of the Manchester Society, v. p. 362.

[2] The rain, at Penzance, in this month, was 1·005 inch.

[3] History of Falmouth (Trathan, Falmouth, 1827), p. 50.

[4] The rain, at Penzance, in this month, was 0.66 inch.

[5] Phil. Mag. and Annals, iii. (1828), p. 182, iv.-v.-vi.-vii.

the surface will be the 0·26 part, or about a quarter of the whole rain falling during the year.

The only other comparisons of the rain with the water filtering into the earth, with which I am acquainted, are by Professor Bischoff; who, from a much smaller surface, calculates the absorption at 0·9[1] foot annually; and states the rain falling in the same neighbourhood at from 20 to 23 inches in the year.[2]

These quantities will give an annual drainage of 39,204 cubic feet, and the rain (taking it at 21·5 inch) as 78,408 cubic feet per acre.

M. Bischoff's observations were made near the banks of the Rhine, where the quantity of rain is scarcely half so much as it is in Cornwall: and the proportion between it and the drainage is as unity to 0·5;—or about one-half the rain falling is absorbed by the earth.

It is somewhat remarkable that there is a coincidence so near as 1·0 : 0·895 between these observations on the quantities of water actually absorbed by the earth, and again given out by springs in Cornwall and at Bonn; whilst the rain falling on the two districts differs at least by one-half.[3]

M. Bischoff, in 1834, made another series of observations on the waters of the Lippe, Raute, Pader, Alme, and Herder, which rise out of the dislocated

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[1] Edin. New Phil. Journal, xxiii. (1837), p. 335. [2] Ibid, p. 338.

[3] The mean annual temperature at Penzance is 52°· (Mr. Giddy, Phil. Mag. and Annals, iii. p. 182.); of Plymouth 52°·081 (Mr. Harris, Reports of the Brit. Assoc., vii. p. 24.); of Lowenburg, near Bonn, M. Bischoff's place of observation, 46°·38 (Edin. New Phil. Journal, xxiv. p. 271.).

sandstone, limestone, and chalk formations of Westphalia, and there found the quantities of water flowing from the springs so great, as to require an absorption of two feet of rain-water per annum for their supply.[1]

Few tracts, of equal extent, afford such facilities as the Gwennap mining district, for comparing the quantity of water falling in rain with that issuing from the rocks and veins at different depths.

This tract includes all the mines which empty their waters into the *great adit*, together with a border having a breadth of about 200 fathoms outside the greater number, if not the whole, of them, and comprizes an area of about 5,550 acres.[2]

The various ramifications of this adit extend between thirty and forty miles on nearly the same plane; and its extreme limits are, in a straight line, about five and a half miles from its mouth. In some parts of its course it is not more than 12 or 15

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[1] He remarks, enquiringly, that in few parts of Germany, where the annual fall of rain is known, is it in sufficient quantity to supply these springs, which rise on the western declivity of the Teutoburger Wald.

Edin. New Phil. Journal, xxiii. p. 338, *note*.

[2] Its limits may be readily traced on Mr. Thomas's excellent and accurate "Geological Map of the Mining district of Cornwall, between Camborne and Chacewater." The points this line will intersect are, the adit's mouth at *Wheal Friendship;* 100 fms. N. of Higher Coisgarne; 100 fms. S. of *South Ale and Cakes;* 80 fms. N. of Trevince; Trevarth; 120 fms. N. of Pennance; the summit of Cairn Marth; 120 fms. W. of *North Bosveal;* the Toll gate, N.E. of Redruth; midway between *Cardrew Downs* and *Wheal Harmony;* 120 fms. W. of *Wheal Maria;* the *Great cross-course*, at 330 fms. N.W. of *Briggan;* 150 fms. N. of *Wheal Barberry;* 300 fms. N. of *Trewan;* 300 fms. N. of *Hallenbeagle;* 250 fms. N. of *Wheal Bissy;* 300 fms. E. of *Wheal Bissy;* 200 fms. W. of the river at Chacewater; 120 fms. W. of the river at Cooshecca; 200 fms. E. of the main adit at *Creegbraws;* 250 fms. E. of the river at *Poldice;* 250 fms. E. of the river at Hayle Mills; whence it returns to the adit's mouth at *Wheal Friendship*.

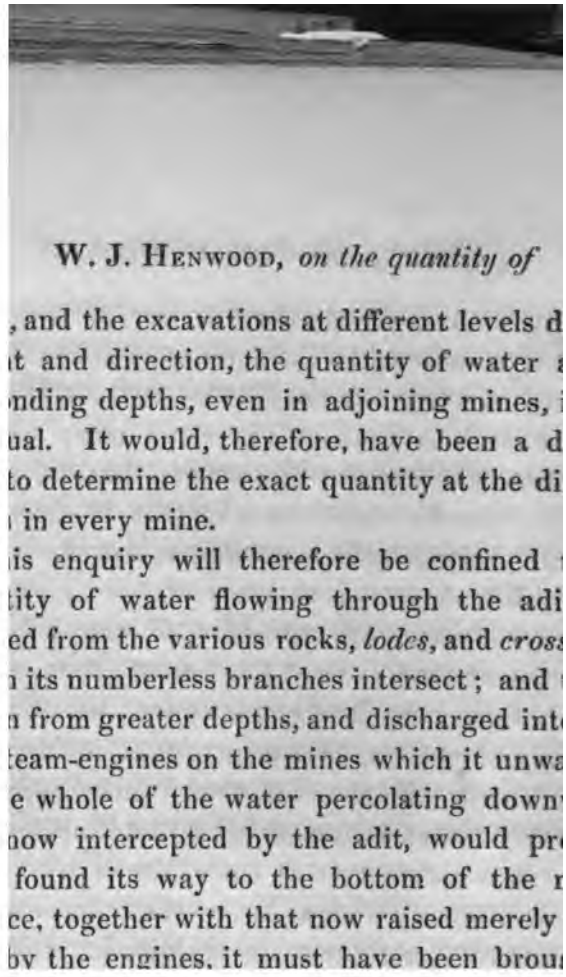
deep; whilst, in the more elevated gr
it penetrates, it is 70 fathoms below th
Throughout the district its average de
y from 35 to 40 fathoms.
than nine-tenths of its extent are worl
but at *Ting Tang*, *Wheal Damsel*, *W*
Poldice, *Wheal Unity*, *Wheal Gorland*, *W*
nd *Treskerby*, it enters the granite. In
it passes through the *elvan-courses*; a
ıe great rock-formations it intersects a
ode and *cross-vein* in the district.
ng the period of my observations the f
es only have been at work: viz., the *Co*
Mines, to a depth of from 250 to 300 fath
ited Mines, from 160 to 220 fathoms;
to 110 fathoms; *Wheal Unity Wood*, 1
homs; *Cardrew Downs*, 100 to 130 fath

abandoned. It is chiefly granitic, and extends from Saint Day westward to the summit of Cairn Marth, and north-westward to the Shallow-adit, on the road from Redruth to Truro. There are many wells in this part; although in the others they are so few that the water for domestic purposes is sometimes brought from great distances, and its scarcity is often severely felt.

The generally porous nature of the *lodes* and *cross-veins* permits the descent of water freely through them: and, consequently, as the mines are gradually deepened, the larger quantity is found in the deepest levels;—of those mines especially which are worked in the schistose slate-rocks. For, as the laminar structure of the rocks is intersected by the *lodes*, and these again by the *cross-veins*, the drainage of a great part of every district is effected whenever these veins are penetrated by the operations of mining.

There is, however, an exception to the generality of this rule, presented by wells at the surface of several of the deepest mines in Cornwall: as at *Wheal Fortune (Consolidated Mines)*, *Wheal Vor*, and *Wheal Reeth*. These must be supposed to derive their supplies from veins of quartz, joints in the rock, or other subterranean channels, not in communication with those other veins which, in some cases at least, are worked to very great depths immediately beneath them.

As there is sometimes but little uniformity in the structure and mineral composition of the rocks and



, and the excavations at different levels d
ıt and direction, the quantity of water
ınding depths, even in adjoining mines,
ual. It would, therefore, have been a d
to determine the exact quantity at the di
ı in every mine.
ıis enquiry will therefore be confined
ity of water flowing through the adi
ed from the various rocks, *lodes*, and *cross*
ı its numberless branches intersect; and
ı from greater depths, and discharged int
team-engines on the mines which it unwa
e whole of the water percolating down
ıow intercepted by the adit, would pr
found its way to the bottom of the
ce, together with that now raised merely
by the engines, it must have been brou

I have already stated[1] that this magnificent undertaking was commenced in the year 1748 by the ancestor of the respected family of Williams of Scorrier House.

Table I. exhibits a comparison between the amount of rain, and the quantities of water discharged by the adit, flowing from the surface, and evaporated: and another, between the whole adit-stream and that portion of it which is pumped by the steam-engines from a mean depth of from 190 to 200 fathoms.

The registers from which I compute the quantities of rain, and the evaporation, are those published by the Royal Institution of Cornwall:[2] and for calculating the latter I employ Mr. Daniell's Tables:[3]— but with an allowance of the 0·47 of the results they give, for the difference between the evaporation from a surface of water, to which they refer, and that from a surface of earth, in conformity with Mr. Dalton's experiments.[4]

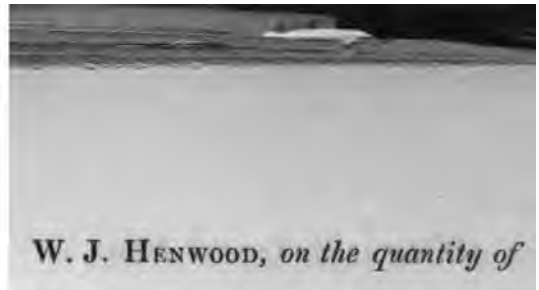
The amount of dew, and the difference between the rain falling on the higher and lower grounds, I am unable to assign. The former is, of course, an addition to the quantity of water deposited on the surface; whilst a reduction should be made for the latter, as the rain-guages I have quoted are placed respectively but 55 and 80 feet above the half-tide

[1] *Ante*, p. 89.*

[2] Reports of the Royal Institution of Cornwall, xxi. (1839), p. 70, and xxii. (1840), p. 82. The evaporation for the four last months of 1839 I am compelled to estimate by interpolation, as the observations then made have not been published.

[3] Meteorological Essays, p. 164.

[4] Memoirs of the Manchester Society, v. 670.



as, therefore, the differences arisin
sources are in opposite directions, th
ıpensate or neutralize each other.

Thomas estimates the average quar
e water flowing through the Carnon v
80 cubic feet per minute.[2] But, as thi
es the drainage of Bostrase moors,
ds east of Chacewater river, and of the
le of the valley which leads from Bissoe
l, all which are beyond our limits, perh
han one-half of the surface water whicl
n valley proceeds from the tract unde
on.

quantity of water drawn out of the n
ed from Messrs. Lean's Report of the
engines, except that from *Cardrew Do*
beagle, which (not being contained

tional area, and experiments on the velocity of the stream, made by myself; and which, in every instance, I have several times carefully repeated.

TABLE I.

	Rain. Cubic feet per minute.	Surface water. Cubic feet per minute.	Evaporation. Cubic feet per minute.	Water discharged by great adit. Cubic feet per minute.	Water drawn from a depth of 190 to 200 fms. Cubic feet per minute.
1839:					
Jan.	1354·	40·	180·	1460·	881·[2]
Feb.	1559·	,,	119·	—	—
March	1711·	,,	134·	1675·	979·
April	1365·	,,	357·	—	—
May	1245·	,,	552·	—	—
June	1958·	,,	506·	1022·	850·
July	2382·	,,	662·	885·	831·
Aug.	1072·	,,	610·	1177·	709·
Sept.	2551·	,,	328·[1]	—	—
Oct.	1570·	,,	166·[1]	1064·	930·
Nov.	3346·	,,	56·[1]	1978·	946·
Dec.	3953·	,,	42·[1]	—	—
1840.					
Jan.	2545·	,,	104·	{ 2898· 1933· }	1119·[3]
Feb.	1786·	,,	119·	—	—
March	92·	,,	295·	{ 2149· 1994· }	1145·[4]
April	352·	,,	283·	1174·	1021·
Mean of year.					
1839	2005·	40·	309·	1323·	875·
From April, 1839, to May, 1840..	1904·	,,	310·	1627·	944·
Means	1954·	40·	310·	1475·	909·
			1825		

1 Interpolated from the temperatures of these months in 1839, and the differences between the wet and dry bulb thermometers for corresponding months in 1840.

2 This observation was made on the morning of the 1st of January; and as the water flowing had been pumped out of the mines in the preceding month, this quantity is from Messrs. Lean's December report.

3 These observations were made on the 1st and 27th of January, and this amount is a mean of Messrs. Lean's quantities for December and January.

4 These experiments were made on the 9th and 27th of March; this result is therefore from Messrs. Lean's March report.

e foregoing table shows that the quan
hich fell on this tract, during the period
ry, exceeded by about the ·066 part the
of the evaporation and streams flowing
urface and adit. The rain is, therefore
ate to the supply of all the springs in th
whether their waters issue at the surfa
ground in the mines.[1]

course, it has been pre-supposed that the
the same state of humidity at the begi
nd of our enquiries: but, as it will be pre
hat the rain requires some time to descen
ines, the water pumped out of them d
tter observations[2] cannot have been the
fell at the time.

e average level of the district is about 15
the rain-guages and thermometers at Alv

tions, the quantity of the former is doubtless somewhat in excess, whilst that of the latter is deficient. The corrections required by these circumstances will reduce the small difference (of ·066) observed within still narrower limits.

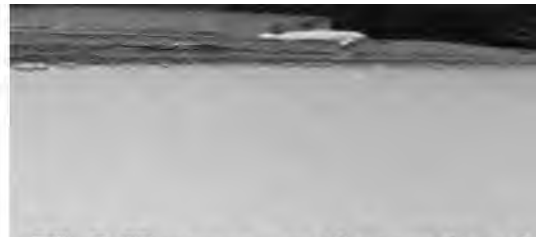
The average annual fall of rain, during the period under consideration, was 51·12 inches.

The average annual evaporation ...	8·1 ins.	or 15·83	℔ cent.
,, water flowing from the surface	1·04 ,,	or 2·03	,,
,, water discharged by the adit ...	38·58 ,,	or 75·42	,,
the difference, unaccounted for....	3·4 ,,	or 6·65	,,
	51·12 ,,	or 100·0	,,

The proportion absorbed by the surface and penetrating to a mean depth of at least 35 fathoms (a very considerable part of it to much greater depths[1]) is 75 per cent.,—or three-fourths of the whole rain which falls. From the facilities which the adit's mouth affords for measurements, and from the care and attention bestowed on my observations, I have much confidence in the accuracy of this conclusion; although it differs so widely from the results obtained elsewhere by other observers.

The necessity for the utmost attention to the state of the surface, in order to prevent as much as possible the absorption of rain-water, has long been recognized. To illustrate its importance, I need only mention the following fact. When, about thirty years ago, the *United Mines* were under the management of Michael Williams, Esq., he found the surface

[1] M. Juncker found that the quantity of water collected in winter at the adit level, 55 fms. deep in Huelgoat mine, was the ·59 of a cubic foot per minute, whilst that pumped from the depth of 170 fms. was 72·4 cubic feet in the same time. Annales des Mines, viii., 3me série (1835), pp. 124–125.



W. J. Henwood, *on the quantity of*

ed by innumerable shallow pits, former
suit of the tin ore which occurs in th
cial parts (the *backs)* of most of the
se pits enormous quantities of rain-wa
; and, being absorbed, inundated the wo
orders they were filled up, and plaster
enaceous clay; and small channels we
aid the general drainage of the uneven s
esult, that Gentleman has informed m
e was enabled to work the mines much
he same machinery:—in fact, to such a
ıld otherwise have required far more p
ry costly engines.

On the rate at which rain-water penetra
ıes.—

quantities of water which simultan
the same mine at different depths ha

TABLE II.

	Dolcoath. 244 fms. deep. Slate and granite.	*Wheal Damsel.* 202 fms. deep. Granite.	*Wheal Reith.* 125 to 189 fms. deep. Granite.	*United Mines.* Slate. 133 to 187 fms. deep. 1	*United Mines.* Slate. 90 fms. deep. 2	*Poldiet.* 135 to 172 fms. deep. Slate and granite.	*Wheal Towan.* 120 to 151 fms. deep. Slate. 3	*Wheal Rose.* 79 to 125 fms. deep. Slate.	*Wheal Hope.* 48 to 129 fms. deep. Slate. 4	*Wheal Harmony* & *Wheal Montague.* 104 to 112 fms. deep. Slate.	*Great Saint George.* 89 to 107 fms. deep. Slate. 5	*Polladras Downs.* 89 to 105 fms. deep. Slate. 6	*Crennis.* Slate. 48 to 112 fms. deep. 7	*Crennis.* Slate. 62 to 103 fms. deep. 8	Means.	Ratio of Rain.
Jan. ..	1·33	1·32	2·05	1·0	1·41	1·32	1·29	1·48	1·37	1·22	1·12	1·36	1·54	2·03	1·31	1·81
Feb. ..	1·23	1·14	1·85	1·23	1·63	1·31	1·09	1·28	1·37	1·22	1·01	1·2	1·46	1·83	1·24	1·52
Mar. ..	1·27	1·34	1·99	1·33	1·75	1·43	1·17	1·5	1·53	1·32	1·09	1·16	1·76	1·95	1·36	1·41
April ..	1·23	1·23	1·38	1·34	1·46	1·24	1·17	1·39	1·4	1·25	1·11	1·29	1·5	1·61	1·23	1·19
May ..	1·24	1·28	1·29	1·48	1·64	1·28	1·24	1·47	1·36	1·2	1·07	1·29	1·31	1·89	1·26	1·19
June ..	1·17	1·28	1·12	1·12	1·31	1·17	1·16	1·2	1·27	1·07	1·12	1·37	1·2	1·57	1·13	1·0
July ..	1·04	1·11	1·04	1·04	1·32	1·16	1·09	1·12	1·13	1·06	1·2	1·16	1·2	1·59	1·07	1·14
Aug. ..	1·0	1·09	1·0	1·38	1·16	1·07	1·04	1·0	1·07	1·08	1·19	1·18	1·12	1·56	1·05	1·58
Sept ..	1·0	1·04	1·07	1·16	1·03	1·0	1·0	1·01	1·0	1·0	1·12	1·18	1·0	1·53	1·0	1·55
Oct. ..	1·02	1·02	1·23	1·25	1·03	1·08	1·06	1·03	1·04	1·08	1·13	1·24	1·1	1·78	1·06	1·95
Nov. ..	1·01	1·0	1·42	1·34	1·05	1·04	1·01	1·1	1·06	1·03	1·04	1·0	1·2	1·0	1·01	1·66
Dec. ..	1·25	1·19	2·3	1·37	1·0	1·18	1·13	1·49	1·26	1·2	1·0	1·0	1·59	1·65	1·23	2·19
Total fluctuation ..	13·79	14·04	17·74	15·04	15·79	14·28	13·45	15·07	14·86	13·73	13·2	14·43	15·98	19·99	13·95	18·19

1 From Feb. 1823 to Oct. 1824.
2 From April 1825 to Nov. 1829.
3 From Jan. 1827 to Nov. 1829.
4 From June 1825 to Nov. 1829.
5 From Nov. 1823 to April 1828.
6 From Nov. 1826 to Nov. 1829.
7 From Dec. 1822 to Nov. 1827.
8 From Dec. 1827 to Nov. 1829.

All the others are for seven years, from Dec. 1822 to Nov. 1829.

ıe foregoing table contains some mines si
ıch of the mining districts, except Sair
Callington: the whole may, therefore, b
ɔd to present a fair average of the Count
ith but three or four exceptions, which
ıfter alluded to, nearly the same period
isite for the appearance of rain-water
s: the interval between the heaviest fall
he largest quantity of water in the mines
t three months; as the greatest quantity
December, and of water in the mines in
tween the month of least rain and that
h the mines yield the smallest quantity of
ırly equal time seems to occur; since th
st in June, and the water in the mines i
ptember. But more minute investigatic
ls of which, however, would here occu

its way to the deepest level, yet the shallower levels, as they are worked for a longer time, and usually extend further than the deep ones, often intercept a considerable quantity. To avoid, as much as possible, the heavy cost of pumping from great depths, the water in the shallower levels is at once conducted to the pumps. On this account, the upper *lifts*, almost without an exception, are larger than the lower.[1] But it may be presumed that the water thus naturally collected at each series *(lift)* of pumps does not always, or indeed commonly, supply neither more nor less than the exact quantity required to fill the pumps. Whilst the water is in excess at one *level*, and for its drainage the pump should be worked rapidly, at others it is often insufficient. When there is such a deficiency an artificial supply is allowed to descend to keep the pumps always filled *(solid)*, lest the buckets, valves *(clacks)*, &c., should be injured by the irregular action of the engine and other apparatus[2] *(going in fork)*.

There is no doubt some difference in the times required for the descent of the water to different depths: but this cannot be ascertained, since the *Reports* furnish little information which can throw any light on the question, and we have no other means for determining it.

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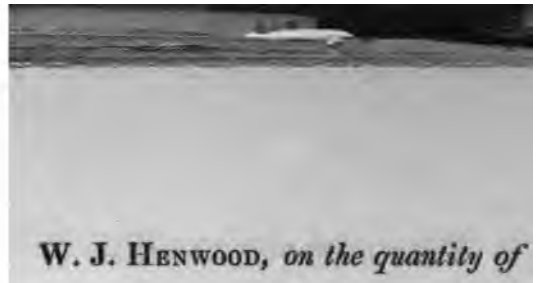
[1] My own Paper, Transactions of Institution of Civil Engineers, ii. p. 56.

[2] M. Juncker found that the quantity of water delivered by the pumps at Huelgoat differed from the estimated quantity by only about 1-30th.
Annales des Mines, viii. (1835), p. 268.

My own experiments at *Wheal Towan* give a difference in this respect of about 1-10th. Transactions of the Institution of Civil Engineers, ii. p. 58, *note*.



particulars of these irregularities n
by personal inspection; for their va
frequent and considerable that the att
rate or describe them would be hopel

On the relations between the depths q
e quantities of water in them.

perpendicular shaft were sunk in a r
homogeneous, and destitute of lam
or veins, the portion drained by it w
erted cone, of which the bottom of t
be the apex, and the surface of the e
The diameter of this base would dep
cility the rock afforded for the des
—The dimensions of this cone wou
he depth of the shaft; and, consequ
ater were solely derived from that
would be a very simple relation betw

position is liable to some variation at almost every fathom. Some of these circumstances impede the drainage, whilst others facilitate it, to almost incredible distances: the figure and extent of the tract which will be drained by any given shaft or series of mining operations can, therefore, be seldom foreseen at the commencement of any undertaking.

To add to the complexity of this enquiry, the horizontal excavations *(levels)* are continually extended, even when the shafts are not sunk deeper: though, in most well-conducted mines, both these operations are carried on at one and the same time.

It is therefore only from a comparison of the quantities of water entering mines which are being sunk deeper, with those, during the same periods, flowing into others, of which the depths remain constant, that we can hope to advance our knowledge of this subject.

Of the mines particularized in Table II., *Dolcoath*, *Wheal Damsel*, the *United Mines* during the second series of observations, and *Crennis* for a considerable portion of the first series, have been worked at the same depths, and thus afford us, if not perfect standards of comparison, at least, the best within our reach.

Table III. indicates the cubic feet of water per minute which enter them, and the rain in inches,[1] at different periods.[2]

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[1] From Mr. Giddy's Register, Phil. Mag. and Annals, iii. (1828), p. 181.

[2] The total quantities are given in the London and Edin. Phil. Mag., i. (1832), p. 289.

TABLE III.

	Dolcoath. 244 fms. deep. Cubic feet per minute.	*Wh. Damsel.* 202 fms. deep. Cubic feet per minute.	*United Mines.* 90 fms. deep. Cubic feet per minute.	*Crennis.* 50 fms. deep. Cubic feet per minute.
Dec.	42·	17·	—	61·
Jan.	38·	18·	—	55·
Feb.	46·	18·	—	71·
March	43·	20·	—	69·
April	36·	18·	—	56·
May	36·	16·	—	49·
June	37·	15·	—	40·
July	32·	14·	—	34·
Aug.	34·	13·	—	32·
Sept.	35·	13·	—	35·
Oct.	36·	13·	—	43·
Nov.	39·	15·	—	54·
Dec.	44·	16·	—	68·
Jan.	40·	17·	—	69·
Feb.	37·	17·	—	61·
March	38·	16·	—	66·
April	42·	17·	—	63·
May	35·	15·	—	53·
June	36·	15·	—	54·
July	36·	16·	—	60·
Aug.	34·	16·	—	57·
Sept.	31·	15·	—	52·

TABLE III. continued.

	Dolcoath. 244 fms. deep. Cubic feet per minute.	*Wh. Damsel.* 202 fms. deep. Cubic feet per minute.	*United Mines.* 90 fms. deep. Cubic feet per minute.	Rain. Inches.
1826, Nov.	25·	12·	56·	4·28
„ Dec.	33·	13·	55·	4·40
1827, Jan.	38·	15·	74·	4·42
„ Feb.	42·	15·	90·	1·60
„ March	45·1	16·	102·	5·26
„ April	40·	16·	109·	1·36
„ May	46·	19·	98·	5·31
„ June	42·	17·	87·	2·16
„ July	34·	15·	83·	2·25
„ Aug.	31·	15·	75·	2·86
„ Sept.	26·	14·	67·	2·82
„ Oct.	26·	14·	60·	6·10
„ Nov.	29·	15·	59·	3·16
„ Dec.	41·	18·	75·	7·58
1828, Jan.	52·	21·	136·	7·45
„ Feb.	49·	21·	186·	4·01
„ March	46·	20·	142·	3·44
„ April	44·1	20·	120·	7·50
„ May	48·	22·	132·	3·76
„ June	50·	22·	136·	1·96
„ July	34·	21·	119·	4·55
„ Aug.	33·	22·	100·	4·57
„ Sept.	32·1	22·	86·	3·04
„ Oct.	35·	21·	82·	3·25
„ Nov.	32·	18·1	81·	3·83
„ Dec.	36·	23·	93·	6·22
1829, Jan.	41·	26·	106·	3·13
„ Feb.	37·	21·1	99·1	3·00
„ March	43·	26·	113·	1·46
„ April	37·1	23·	106·	5·50
„ May	35·	24·	119·	0·56
„ June	33·	22·	100·	4·48
„ July	32·	17·	91·	5·61
„ Aug.	30·	17·	84·	5·51
„ Sept.	43·	18·	88·	6·82
„ Oct.	33·	19·	96·	3·03
„ Nov.	39·	19·	100·	1·64

1 The interpolations for *Dolcoath* are made by comparison with *Wheal Damsel*; those of *Wheal Damsel* with *Poldice*; and those of the *United Mines* with *Wheal Harmony*.

Table IV. indicates the proportionate quantities of water drawn out of each mine, and of rain in the different years; and in either case, as in Table II.,

allest quantity is taken as unity. B
rs from Table II. that the intervals betw
a and *minima* in the different mines are
the column of *rain* always shows the
hich fell just as many months before a
uired for its descent;—which rain, th
e considered the same water which
pumped out of the mines.

TABLE IV.

	Dolcoath.		*Wheal Damsel.*	*United Mines.*	Rain ratio.	*Crennis.*		
	Ratios of		Ratio of	Ratio of		Ratios of		
	Water drawn.	Rain.	Water drawn.	Water drawn.		Water drawn.	Rain.	W dr
	1·11	1·65	1·03	—	1·48	1·0	1·2	
	1·07	1·39	1·04	—	1·41	1·2	1·14	
	1·0	1·19	1·04	1·351	1·23	1·16	1·0	1
	1·0	1·0	1·16	1·25	1·0	—	—	1

TABLE V.

	Wheal Reeth.		*Wheal Rose.*		*Wheal Hope.*	
	Depth fms.	Cubic feet per minute.	Depth fms.	Cubic feet per minute.	Depth fms.	Cubic feet per minute.
1822, Dec.	125·	20·	79·	80·	—	—
1823, Jan.	,,	14·	,,	82·	—	—
,, Feb.	,,	22·	,,	94·1	—	—
,, March	,,	16·	,,	75·	—	—
,, April	,,	10·	,,	80·	—	—
,, May	127·	8·	87·	78·	—	—
,, June	135·	6·	,,	73·	—	—
,, July	,,	5·	,,	79·1	—	—
,, Aug.	,,	7·	,,	72·1	—	—
,, Sept.	,,	9·	104·	60·	—	—
,, Oct.	145·	12·	,,	62·	—	—
,, Nov.	,,	13·	,,	59·	—	—
,, Dec.	149·	15·	,,	83·	—	—
1824, Jan.	,,	13·	,,	91·	—	—
,, Feb.	,,	10·	,,	82·	—	—
,, March	,,	13·	,,	80·	—	—
,, April	,,	9·	,,	84·	—	—
,, May	,,	8·	,,	81·1	—	—
,, June	,,	8·	,,	75·1	—	—
,, July	,,	9·	,,	80·1	—	—
,, Aug.	,,	7·	55·	35·	—	—
,, Sept.	,,	6·	,,	35·	—	—
,, Oct.	,,	9·	59·	36·	—	—
,, Nov.	,,	12·	63·	41·	—	—
,, Dec.	,,	19·	64·	60·	—	—
1825, Jan.	,,	14·	,,	60·	—	—
,, Feb.	,,	15·	,,	58·	—	—
,, March	,,	12·	,,	52·	—	—
,, April	,,	8·	70·	52·	—	—
,, May	,,	7·	,,	56·1	—	—
, June	,,	6·	,,	43·	48·	39·
,, July	,,	6·	72·	39·	53·	33·
,, Aug.	,,	5·	,,	36·	55·	33·
,, Sept.	,,	5·	76·	36·	56·	31·
,, Oct.	,,	5·	,,	36·	,,	31·
,, Nov.	,,	7·	,,	38·	,,	31·
,, Dec.	,,	12·	,,	41·	66·	46·
1826, Jan.	169·	11·	,,	51·	74·	54·
,, Feb.	,,	15·	,,	50·	,,	52·
,, March	,,	13·	,,	51·	,,	57·
,, April	,,	8·	,,	44·	,,	53·
,, May	,,	6·	,,	42·1	,,	47·
,, June	,,	7·	,,	43·	,,	43·1
,, July	,,	6·	85·	42·	,,	39·
,, Aug.	,,	5·	,,	40·	,,	35·
,, Sept.	,,	5·	,,	39·	,,	37·
,, Oct.	,,	5·	,,	41·	77·	37·

TABLE V. continued.

	Wheal Reeth.		*Wheal Rose.*		*Wheal*	
	Depth fms.	Cubic feet per minute.	Depth fms.	Cubic feet per minute.	Depth fms.	C pe
Nov.	169·	4·	85·	40·1	77·	
Dec.	,,	11·	,,	42·1	,,	
Jan.	,,	11·	,,	49·	,,	
Feb.	,,	12·	,,	42·	,,	
March	,,	16·	,,	50·1	,,	
April	,,	10·	,,	56·	,,	
May	,,	12·	91·	53·	,,	
June	,,	10·	94·	52·	,,	
July	,,	8·	95·	52·	,,	
Aug.	,,	5·	,,	55·1	,,	
Sept.	,,	6·	,,	44·	,,	
Oct.	,,	8·	,,	42·	,,	
Nov.	,,	11·	,,	46·1	,,	
Dec.	,,	18·	,,	58·1	88·	
Jan.	,,	22·	85·	71·	,,	
Feb.	,,	20·1	90·	77·	108·	
March	,,	11·	,,	73·	,,	
April	,,	12·	100·	69·	,,	
May	,,	13·	,,	69·	,,	
June	,,	9·	95·	65·	112·	
July	,,	8·	101·	60·	,,	
Aug.	,,	8·	95·	57·	,,	

the mode of stating them is the same as in Tables II. and IV.

TABLE VI.

Years.	*Wheal Reeth.*			*Wheal Rose.*			*Wheal Hope.*			Means.		
	Depth fms.	Ratios of Water drawn	Rain.	Depth fms.	Ratios of Water drawn	Rain.	Depth fms.	Ratios of Water drawn	Rain.	Depth fms.	Ratios of Water drawn	Rain.
1823..	132·	1·5	1·62	88·	1·7	1·65	—	—	—	—	—	—
1824..	149·	1·25	1·55	89·	1·52	1·39	—	—	—	—	—	—
1825..	„	1·12	1·21	70·	1·07	1·19	54·	1·01	1·23	91·	1·0	1·21
1826..	169·	1·0	1·0	80·	1·0	1·0	74·	1·36	1·0	108.	1·06	1·0
1827..	„	1·25	1·26	90·	1·11	1·23	77·	1·85	1·16	112.	1·32	1·22
1828..	„	1·5	1·66	95·	1·44	1·57	107·	1·9	1·61	124·	1·51	1·61
1829..	182·	1·33	1·41	108·	1·34	1·42	119·	1·47	1·29	136·	1·3	1·37
Sums of the variations..	—	8·95	9·71	—	9·18	9·45	—	7·58	6·29	—	6·19	6·41
Means..	160·	1·28	1·39	88·	1·31	1·35	86·	1·51	1·26	114·	1·238	1·282

1 For the six last months.

In Table IV. the ratios of water pumped out of the mines in different years are for depths *constant* during the whole period;[1] whilst those in Table VI. are for depths progressively *increasing* from 91 to 136 fathoms. If, therefore, the difference of depth has no effect on the quantity of water entering the mines, the *means* will be in the same proportion for every year; but, if the increased depth occasions an increase in the quantity, the *means* in Table VI. will exceed those in Table IV., and this excess will be the measure of the influence.

1 M. Daubuisson has treated largely of the water in the Saxon mines. *Des Mines de Freiberg*, i. p. 233; iii. pp. 34-87-165-199-235-255-278.

w, in the mines of which the depths rem
ant, the mean of five years' observations (
s 1·144; whilst, for the same period, i
s which had been sunk from 91 to 136 fat
n average depth of 114 fathoms, it is
difference (·094), which is nearly one-te
hole quantity, is therefore due to an in
fathoms in depth.[1]

the London and Edinburgh Philoso
zine, I. (1832), p. 294, I have stated the
of water pumped out of the same m
examining the subject in a somewhat dif
er, I found that the same addition of
ased the quantity of water by ·101: an ap
on sufficiently near to my present results.

. *On the rates of absorption by different*
n the differences in the quantities of water

in one in the sixth,—and in another in the seventh month after the greatest fall of rain.

In the following table will be found a summary of monthly observations on the depth of water in wells in the years 1832–3. That at Falmouth was made by Robert Were Fox, Esq.; at Mellingye, in Perran-ar-worthal, by Mr. Thomas; at Bodmin by Dr. Potts; at Tregaswith, near St. Columb, by Mr. Grigg; and those at the Lizard Light-house and Landewednack were by the late Rev. H. T. Coulson:—the others, on wells in Perran-ar-worthal and Stythians, are my own.[1]

When the measurements made in October and November are compared, a remarkable fact presents itself: the water in all the wells situated in rocks of the slate series, with but a single exception, had diminished; whilst, during the same period, that in the well in serpentine, at Landewednack,—and in all those in the granite of Stythians, had considerably increased.

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[1] Observations on the depth of water in a well at Sydney, New South Wales, were made in 1824-5 by Sir Thomas M. Brisbane, Bt., K.C.B., Edin. Journal of Science, vi. (1827), p. 226; and in wells in Kent by Mr. Bland, Phil. Mag. and Annals, xi. (1832), p. 88.

TABLE VII.

	Bodmin.	Tregas-with.	Perran Church-town.	Perran Wharf.	Tanner's Downs.	Lower Pollean.	Higher Pollean.	Mellin-gey.	Fal-mouth.	Lizard Light-houses.	Lande-wednack	Trebur-ber.	Davis.	Tubban	Geon-hingey.	Chy-weeln.	
Rock....	Slate.	Slate.	Slate.	Slate.	Slate.	Slate.	Slate.	Slate.	Slate.	Horn-blende slate.	Serpen-tine.	Granite.	Granite.	Granite.	Granite.	Granite.	Rain.
Surface above the sea. Feet.	315·0	150·0	60·0	65·0	110·0	110·0	200·0	90·0	120·0	150·0	300·0	280 0	300·0	340·0	560·0	560·0	Inches.
Depth of well. Ft.	73·0	50·5	35·5	59·6	23·4	21·8	56·3	66·0	51·0	40·0	14·0	23·7	30·7	51·5	28·4	35·1	
1832.																	
Feb. ..	48·0	—	—	—	—	—	—	—	—	—	13·5	—	—	—	—	—	2·31
Mar. ..	47·0	24·1	11·0	28·0	5·5	7·1	17·3	—	6·4	15·0	10·4	10·1	6·6	10·5	14·1	8·7	4·47
April ..	45·5	25·8	12·6	29·7	6·5	9·0	20·6	16·7	7·0	15·0	9·5	11·7	7·5	12·1	15·1	9·5	2·9
May ..	37·6	19·3	11·2	24·1	5·0	6·1	14·5	13·5	3·8	12·4	9·5	8·2	4·7	8·5	10·5	6·5	4·22
June ..	38·5	17·9	9·9	23·9	4·6	6 2	13·0	13·3	3·1	10·6	9·0	7·3	5·1	9·5	10·5	7·0	2·52
July ..	40·6	15·6	8·3	19·9	4·1	5·1	11·3	11·1	2·8	7·6	4·5	—	—	—	—	—	2·1
Aug. ..	43·4	10·6	3·3	15·1	3·1	4·0	8·9	7·5	2·5	6·0	2·7	4·0	2·9	6·9	6·5	4·7	5·81
Sept. ..	41·6	14·5	8·4	14·6	2·8	3·6	6·4	11·2	3·1	5·8	1·6	2·8	2·9	5·7	5·5	10·2	0·98
Oct. ..	42·5	13·3	1·7	12·6	1·9	3·0	4·9	5·8	2·2	4·2	dry	2·1	2·7	5·7	5·9	5·1	3·62
Nov. ..	28·7	11·6	4·1	10·4	0·8	2·0	3·3	4·9	2·1	1·8	1·0	3·5	3·5	7·3	7·2	7·6	6·89
Dec. ..	58·5	27·7	12·6	35·1	8·8	11·2	17·2	25·2	9·0	11·5	12·1	14·9	14·0	22 6	21·0	17·4	6·09
1833.																	
Jan. ..	56·6	33·7	17·9	47·5	9·8	12·7	30·4	28·1	13·1	21·8	12·6	17·7	15·5	25·2	23·0	16·5	3·72
Feb. ..	—	25·7	15·7	47·3	8·9	11·8	25·2	16·3	5·9	26·1	full	14·1	12·3	21·4	20·5	15·5	9·73
Mar. ..	—	—	—	—	—	—	—	27·6	16 5	27·0	full	—	—	—	—	—	5·65

The foregoing numbers denote the depth, in feet, of water in the wells. The wells denoted in columns 4 to 9 are within a mile of each other: those in columns 13 to 17 are within a circuit of three miles. The rain is from Mr. Giddy's Register kept at Penzance.

In shallow wells and in deep mines the result, then, is the same:—that the rain-water is more readily absorbed by, and percolates more freely through, the rocks of the granitic formation than those of the slate series.

The most cursory inspection of Tables III. and V. clearly indicates a remarkable difference between the quantities of water pumped out of *Wheal Damsel* and *Wheal Reeth*, which are wholly in granite,—and also *Dolcoath* which is partly so; and those out of the *United Mines*, *Crennis*, *Wheal Rose*, and *Wheal Hope*, which are entirely in the slate formation.

Although the following abstract of the cubic feet of water per minute drawn out of each mine does not pretend to assign the exact proportion between the quantities flowing from the different rocks throughout Cornwall, it is sufficient to show that a striking difference prevails.

Granite.

Wheal Damsel	17	cubic feet ℔ minute.
Wheal Reeth	10	,,
Dolcoath	37	,,
Means	21·3	,,

Slate.

United Mines	101	cubic feet ℔ minute.
Crennis	56	,,
Wheal Rose	57	,,
Wheal Hope	52	,,
Means	64·5	,,

the barometer is low than when it is high.[1] M. Elie de Beaumont has also remarked[2] that the less the atmospheric pressure, the greater the quantity of water which flows into the salt-mines at Bex,[3] and *vice versâ*.

I have been furnished[4] with daily records of the water pumped out of the *Consolidated Mines* during several years, and I have carefully compared them with registers of the barometer for the same periods, but I have failed to discover any relation between the quantity of water in the mines and the height of the barometer. That such a dependence exists, is a general fact which admits of no doubt: but I am unable to determine whether, in this instance, it is concealed by irregularities in the percolation of the water, or whether the time required for the penetration of rain-water retards the appearance of the winter's rain in the deeper parts of the mines until the following spring, when the atmospheric pressure has again increased.

Some of the foregoing deductions seem to have a practical bearing on the economy of mining. They, however, throw no light on the appearance of springs in situations so elevated, that the rain falling on limited tracts above them seems scarcely

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1 Report of the Parliamentary Committee, on accidents in mines, pp. 54–110–111–112.

2 Annales des Mines, ix. (1824), p. 694.

3 It appears that a rise of one inch in the barometer depresses the tide at Bristol about fifteen inches.

Mr. Whewell's Report on Tides,—Reports of Brit. Assoc. for 1841, p. 30.

4 Through the kindness of Captain Francis.

ent for their supply.[1] This is a su
interest; but beset with difficulties
ing of solution, in the present state
edge.

W. J. HENW

RENCE-STREET, PENZANCE,
843, FEBRUARY 22nd.

Forrett divided a jar into two cells by means of a piece o
one cell was filled with water, whilst but a few drops w
The former was connected with the positive pole of a
latter with the negative. After some time he found that t
e cell was gradually transferred to the negative, through
d been water tight until placed within the voltaic circ
be conveyed into the negative cell until its surface there

APPENDIX.

No. 3.

On the electric currents observed in rocks and veins.

In the year 1830, the existence of electric currents was discovered in the metallic portions of several copper and lead *lodes* in Cornwall, by Robert Were Fox, Esq.;[1] and he has since succeeded in imparting magnetism to an iron bar by their agency.[2] He failed, however, to detect their presence, either in tin *lodes*,[3]—in the earthy ingredients of any other *lodes*,[4]—or in the rocks which they traverse.

In the same year, he discovered electric currents in the lead veins of *Lagylass* and *Frongoch*, in the clay-slate of Cardiganshire; but failed, in similar trials, at *South Mold* and *Milwr*,—lead mines which are worked in the limestone of Flintshire.[5]

In 1833, Capt. Bennetts obtained similar results in the copper *veins* at *Wheal Vyvyan*;[6] and, in 1841, Messrs. Hunt and Phillips were equally successful in experimenting on the copper *lode* at *East Pool*,[7]

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[1] Phil Trans. (1830), p. 399. [2] Report of Royal Corn. Pol. Soc. (1841), p. 164.
[3] Phil. Trans. (1830), p. 411, *fig.* 11. [4] Ibid, p. 400.
[5] Corn. Geo. Trans., iv. p. 21. [6] Lond. & Edin. Phil. Mag., iii. (1833), p. 17.
[7] Report of the Royal Corn. Polytech. Soc. (1841), p. 159.

In 1839, Professor Reich conducted a very extensive series of experiments on the N. and S. vein of *Frisch Glück*, which chiefly yields galena, but also some blende, and iron and arsenical pyrites;—on the *Neu Hoffnung* vein, which bears about S.E. and N.W., and is composed of sulphate of barytes, fluor, and a little galena, but where this is crossed by other veins, it is rich in red and vitreous silver ores, and contains also iron pyrites;—in *Gotlob* E. and W. vein, which yields galena;—and in *Ludwig* N. and S. vein, which affords carbonate of iron: all these veins occur in the *Himmelfahrt* mine, which is worked in gneiss, near Freyberg, in Saxony.[1] His admirable investigations not only indicated the existence of electric currents in all these *veins*, and in their different *metallic* ingredients, but also, for the first time, showed similar results when masses of the different ores were connected (through the medium of the galvanometer) with the *earthy* ingredients of the veins, and also with the *rock* which they traverse. Professor Reich does not, however, seem to have ascertained whether or not two non-metallic masses, when thus connected, exhibit electric action.

The experiments described in the following pages were commenced in 1830,—shortly after the first announcement of Mr. R. W. Fox's discovery, and the last of them was made in 1840. They extend to every mining district within the Duchy of Cornwall, except those of Helston and Saint Austell.

[1] Edin. New Phil. Journal, xxviii. (1839), p. 1: Reports of the British Association (1839), p. 34.

all cases the mode of experiment was m
. Plates of common sheet copper were
ed on those points of which the electri
the object of investigation, and suppor
of wood: the plates were connected w
nometer by means of copper wires 1–20
inch in diameter,[1] which were also pr
the influence of contact with any other e
ances by supports of wood.
e galvanometer employed in my earlier
s was kindly presented to me by Mr. R. W
ike his own,[2] was contained in a box m
copper. The needle was a thin bar ab
s long, and 3–16ths of an inch wide:
orted on a point, and its directive pow
neutralized: it was surrounded by 55
er wire of about 1–50th of an inch in di

between the electricity observed in the metallic or earthy portions of the *lodes*, or in the rocks which they traverse, before we can apply our knowledge of their existence to any practical purpose, or assign their office in the economy of Nature.

In Table I., I have so arranged all these particulars of my own experiments, made with plates of copper only, that the influence of any of them on the observed results may become apparent.

(A.) *Experiments with plates and wires of similar metals.*—

The directions, dips, and ingredients of the *lodes*, and also the temperatures and distances of the stations, seem to be circumstances on which the directions and quantities of the electricity may, perhaps, depend.

(I.) Table I. contains the details of twenty-six experiments made on the currents, horizontally, traversing sixteen *lodes*.

	Lodes bearing N. of W.	*Deflection.*
Currents from	E. to W. .. 4, or 15·4 ℔ cent.	.. 90°.[1]
,,	W. to E. .. 5, ,, 19·2 ,,	.. 40°.
	Lodes bearing E. and W.	
,,	E. to W. .. 2, or 7·7 ,,	.. 31°.
	Lodes bearing S. of W.	
,,	E. to W. .. 5, or 19·2 ,,	.. 57°.
,,	W. to E. .. 10, ,, 38·5 ,,	.. 73°.

In these observations, therefore, the proportions were 15, or 57·7 per cent., in which the currents flowed from W. to E., and 11, or 42·3 per cent., in which they were from E. to W.

---

[2] These results were obtained with Messrs. Watkins and Hill's galvanometer; and are, therefore, scarcely comparable with the others.

) Sixteen observations have been mad
cal currents; in 9, or 56·3 per cent., th
ıward direction, and in 7, or 43·7 per
ard one.

	Lodes bearing N. of W.			D
Currents	upward	.. 2, or 12·5 ℔ cent.		.
,,	downward	.. 1, ,, 6·2	,,	..
	Lodes bearing S. of W.			
,,	upward	.. 5, or 31·3	,,	..
,,	downward	.. 8, ,, 50·0	,,	..

I.) Twenty-six observations were mad
tions of electric currents flowing horiz
—17 in *lodes* dipping towards points
ıern side of an E. and W. line, and 9
ıg an opposite dip.[1]

	Lodes dipping N.		
Currents	from E. to W.	.. 10, or 38·4 ℔ cent.	. .
,,	W. to E.	.. 7, ,, 27·0 ,,	..
	Lodes dipping S.		
,,	E. to W.	. 1, or 3·8 ,,	..
,,	W. to E.	.. 8, ,, 30·8 ,,	..

		Lodes dipping N.	*Deflection.*
Currents	upward	.. 5, or 31·2 ℔ cent.	.. 53°.
,,	downward	.. 3, ,, 18·8 ,,	.. 76°.
		Lodes dipping S.	
,,	upward	.. 2, or 12·5 ,,	.. 90°.
,,	downward	.. 6, ,, 37·5 ,,	.. 60°.

(2.) In three mines only have I been able to connect two *lodes* at similar levels: in these I have made five experiments, in every one of which the currents passed from the northern to the southern point;—the mean deflection of the galvanometer needle was 80°.[1]

(3.) I have connected points in parallel *lodes* at different levels in but three mines; and on these I have made six experiments: in one case (16·6 per cent.) the current was ascending, but in the other five (83·4 per cent.) they descended.[2]

(III.) Mr. R. W. Fox has described the ores on which his experiments at *Wheal Jewel* were made,[3] and he has also noticed the ingredients of the *lodes* at *Pennance;*[4] Capt. Bennetts has likewise given a general notice of the composition of the *lode* at *Wheal Vyvyan:*[5] but the probability that the directions and quantities of the electricity in *lodes* may be affected by any other differences in their mineral

[1] Mr. R. W. Fox particularizes four experiments in which he compared the electricity of parallel *lodes:* in two of them the currents flowed from N. to S., and in the others in the opposite direction.

[2] Mr. R. W. Fox records four mines, in which he instituted eight comparisons between the electric conditions of points, at different depths, in parallel *lodes:* in four of them the currents ascended, whilst in the others they descended.

[3] Reports of the British Association (1834), p. 572.

[4] Report of the Royal Cornwall Polytechnic Society (1841), p. 163.

[5] London and Edin. Phil. Mag., iii. (1833), p. 17.

composition, than the presence of a larger or smaller quantity of ore, seems not to have been considered.

These particulars, have, however, been thought of much importance by the German observers; for M. Von Strombeck and Professor Reich have described all the chief ingredients of those parts of the *lodes* on which they experimented.

Since, in all Mr. R. W. Fox's experiments, as well as in a great number of my own, the apparatus employed by us was not sufficiently delicate to detect the existence of currents in the *rocks* and *earthy* constituents of the *lodes*, it is evidently useless to attempt to discover, in the results so obtained, differences in the directions and quantities of electricity in *lodes* which differ only in their earthy minerals. I have, accordingly, made comparisons only between *lodes* which present well marked and unmistakable differences in their *metallic* portions.

(1.) In fourteen instances I have connected those points in the same *lodes* which had similar mineral characters, and which were separated neither by *cross-veins* nor any unproductive parts of the *lodes*.

The results are given in the following columns; and, in cases where the points connected were neither in the same vertical nor horizontal planes, I have stated the direction of the current in reference to both.

	Lodes dipping N.		*Deflection.*
Currents from E. to W. ..	5, or 33·3	per cent. ..	51°.
„ W. to E. ..	2, „ 13·3	„ ..	48°.
„ downward	1, „ 6·7	„ ..	90°.
No electric action	3, „ 20·0	„ ..	—

	Lodes dipping S.	*Deflection.*
Currents from W. to E.	.. 2, or 13·3 ℔ cent.	.. 90°.
,, downward	..... 1, ,, 6·7 ,,	.. 90°.
No electric action	..... 1, ,, 6·7 ,,	

(2.) In like manner I have, in thirteen instances, connected portions of the same *lodes* containing different metallic minerals; but in only a single instance was the difference very great. Here, also, when the points connected were not in either the same vertical or horizontal plane, I have mentioned the direction of the current with regard to both these planes.

	Lodes dipping N.	*Deflection.*
Currents from E. to W.	.. 3, or 14·3 ℔ cent.	.. 81°.
,, W. to E.	.. 1, ,, 4·7 ,,	.. 40°.
,, downward	. 1, ,, 4·7 ,,	.. 62°.
,, upward	.. 1, ,, 4·7 ,,	.. 40°.
	Lodes dipping S.	
,, E. to W.	. 3, or 14·3 ,,	.. 59°.
,, W. to E.	.. 5, ,, 24·0 ,,	.. 60°.
,, downward	.. 4, ,, 19·0 ,,	.. 52°.
,, upward	.. 3, ,, 14·3 ,,	.. 59°.

I must remark that, in every experiment in which the ores were different at the points examined, I have found traces of electricity.

(3.) In six cases I have compared points in different *lodes* composed of dissimilar ingredients. In five of them one *lode* dipped N. and the other S.: and, in every instance, the currents flowed from the former towards the latter; and from W. to S.E. In two the points of comparison were at equal depths; but in the other three, and also in the sixth example, they were at different depths:—in all, however, the currents flowed downward; the deflection of the

galvanometer, in the horizontal currents, averaging 80°, and in the vertical ones, 73°.

We have thus nineteen instances of electric currents existing between points of different mineral composition: their directions are, in—

7, or 37·5 ℔ cent., from copper pyrites, towards blende.[1]
1, ,, 5·2 ,, from copper pyrites and galena, towards the same substances mixed with blende.
1, ,, 5·2 ,, from copper pyrites, towards copper and iron pyrites, galena, and blende.
1, ,, 5·2 ,, from copper pyrites and vitreous copper ore, towards copper pyrites and galena.
1, ,, 5·2 ,, from black copper ore, towards black copper ore, copper pyrites, and galena.
1, ,, 5·2 ,, from iron pyrites with a little black copper ore, towards black copper ore and iron pyrites.
1, ,, 5·2 ,, from iron and copper pyrites, towards copper and iron pyrites.
1, ,, 5·2 ,, from oxide of tin and iron pyrites, towards oxide of tin.
2, ,, 10·5 ,, from vitreous copper ore, towards the same substance mixed with oxide of tin.
1, ,, 5·2 ,, from oxide of tin and vitreous copper ore, towards vitreous copper ore.
1, ,, 5·2 ,, from black copper ore, galena, and copper pyrites, towards black copper ore.
1, ,, 5·2 ,, from blende, towards copper pyrites.

(IV.) Intimately connected with the last subject, but one of far greater practical importance, is the enquiry whether the direction or quantity of electricity has any relation to the positions of the largest masses of ore.[2] We have twenty-five experiments

[1] Professor Reich also found the currents, in several instances, flowing towards the blende, during his experiments in the mine *Himmelfahrt*.
Edin. New Phil. Journal, xxviii. (1839), p. 1.

[2] Mr. R. W. Fox, Phil. Trans. (1830), p. 400.

on *lodes*, of which the richest parts are known with tolerable certainty: the following is a statement of the directions and quantities of the electricity observed in them:[1]—

		Deflection.
	Lodes dipping N.	
Currents towards the richest part	.. 8, or 22·2 ℔ cent.	.. 49°.
,, from ,,	.. 8, ,, 22·2 ,,	.. 62°.
,, upward	..... 4, or 11·1 ,,	.. 53°.
,, downward	..... 4, ,, 11·1 ,,	.. 76°.
	Lodes dipping S.	
,, towards the richest part	.. 4, or 11·1 ,,	.. 52°.
,, from ,,	.. 3, ,, 8·3 ,,	.. 80°.
,, downward	..... 5, ,, 14·0 ,,	.. 70°.

(V.) It has been shown in the foregoing pages[2] that the dip of the *lodes*, and the position *(shoots)* of the ores they contain, have reference to the situation of granitic rocks in their vicinity; and, also, that at equal depths, the temperature of the granite is lower than that of the slate.[3] It becomes, therefore, an object of much interest to ascertain whether the directions and quantities of the electricity circulating through the *lodes* may have any relation to

[1] "By connecting a galena point of *Frisch Glück* with non-metalliferous "heavy-spar in *Neu Hoffnung* (we obtained) a deviation of 10°; the *Berg-* "*meister*, Mr. Fischer, ordered this point to be worked out, and at 0·8 m. "(about 5 inches) distance, dark and light red silver ores, and silver-glance, "were found, which otherwise should *never* have been won.

"A result so favourable seemed naturally to demand a further research into "the matter; still it cannot be denied that several other facts very much de- "creased the hope of the probability of an application of this means for the "discovery of hidden ores. For example, on the 4th drift, a galena point in "*Frisch Glück* was connected with non-metalliferous heavy spar in the sole of "*Neu Hoffnung*, beneath which at 8 metres' (about 26 feet) distance, the exist- "ence of rich silver ores was known of, without any trace of an action being "obtained, although in the vicinity upon iron pyrites, in a cross vein of quartz, "20° deviation was obtained. The distance of the ore must, then, be very "short, in order to have any indication of it by a current."

PROF. REICH, *Edin. New Phil. Journal*, xxviii. (1839), p. 11.

[2] *Ante*, pp. 193-245. [3] *Ante*, p. 403.

the granitic rocks in their respective neighbourhoods.

The following columns indicate the directions and quantities of the electricity flowing from one to the other, when the points connected are situated in the same *lodes*.

			Deflection.
	Lodes dipping N.		
Currents towards granite ..	5, or 15·1 ℔ cent.	..	62°.
,, from ,, ..	10, ,, 30·3 ,,	..	58°.
,, upward	3, ,, 9·1 ,,	..	42°.
,, downward	3, ,, 9·1 ,,	..	76°.
	Lodes dipping S.		
,, towards granite ..	7, or 21·3 ,,	..	64°.
,, downward	5, ,, 15·1 ,,	..	54°.

There are, however, many *lodes* which run nearly parallel to the *strike* of the granitic ranges: no relations have been discovered between the directions of the electric currents in these and the positions of the granite near them.

(1.) We have eleven examples of parallel *lodes*, united under circumstances which admit of our examining whether the electric currents passing between them flow towards or from the nearest granitic masses.

In five instances the currents tended towards, and and in six from, the granite; whilst, in all of them, with but a single exception, they were descending.

(VI.) It is well known that the temperature of the earth increases as we descend; and, also, that inequalities of temperature often give birth to electric currents. It may, therefore, not be without interest to ascertain the directions of the currents in those portions of the *lodes* which have been observed to possess different temperatures.

I have made fourteen experiments on portions of the same *lodes*, in which inequalities of temperature were observed. The directions and quantities of the electricity were,[1]—

Direction of current.			*Deflection.*
From colder towards warmer point,	10, or 71·4 ℔ cent.	..	80°.
,, warmer towards colder ,,	4, ,, 28·6 ,,	..	63°.

In three of the four instances in which the currents flow towards the colder points, the latter occupied the deeper situation; in consequence, probably, of imperfect ventilation, which reversed the natural order of subterranean temperature.

(1.) I have examined the electric currents, between points of unequal temperatures, in different *lodes*, in seven instances.[2]

In 4, or 57·1 ℔ cent.,	they have been	from the warmer towards the colder point.
,, 3, ,, 42·9 ,,	,,	from the colder towards the warmer point.

Here, also, the temperatures of the upper stations exceeded those of the lower ones in three of the four cases in which the currents flowed towards the colder points.

The quantities of electricity seemed much the same in both instances.

We have, therefore, in the whole, thirty-three experiments on points at different temperatures; and

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1 Mr. R. W. Fox records eleven experiments in which the unequal temperatures of connected portions of the same *lodes* were observed.

In 9, or 81·8 ℔ cent., the currents flowed towards the warmer point; and
,, 2, ,, 18·2 ,, ,, colder.
In one of the latter the lower temperature prevailed at the deeper point.

2 Mr. R. W. Fox has recorded only one instance of this kind, and in this the current flowed towards the colder point,—which was also the deeper one.

or 66·7 per cent., the currents have be
the warmer, and in 11, or 33·3 per
ds the colder, points.

, if we regard the natural distributi
ranean temperature, and suppose the
is to have possessed the more elevated
ire accidentally, and merely in conseq
perfect ventilation, we shall have the pr
f—

or 91 ⅌ cent., currents towards the warmer points, a
,, 9 ,, towards the colder.[1]

I.) The only remaining question is, wh
uantities of electricity are influenced b
ces between the spots connected.

following is a comparison of the defle
galvanometer when the stations are less
thoms apart, and when they are more tha

In an attempt to effect chemical decomposition by passing the electricity from the *Caunter lode* at *East Wheal Crofty* over paper moistened with a concentrated solution of the iodide of potassium,[1] the result was indecisive. Mr. Hunt, also, says[2] that his experiment on the decomposition of the sulphate of copper afforded but a slight deposit of the metal. We therefore, at present, possess no sufficient means of estimating the *intensity* of the electric currents in *lodes;* the trifling effects noticed by Mr. Hunt and myself seem, however, to intimate that the intensity is not very great.

(B.) In every case in which I used Messrs. Watkins and Hill's galvanometer, I detected the presence of electricity. In the rocks, however, it was far less abundant than in the *lodes.* Nevertheless, whilst a single metal was the medium of communication, its direction was the same in both;—with a single exception, in which, contrary to the general direction of the currents, it flowed from the warmer towards the colder station.

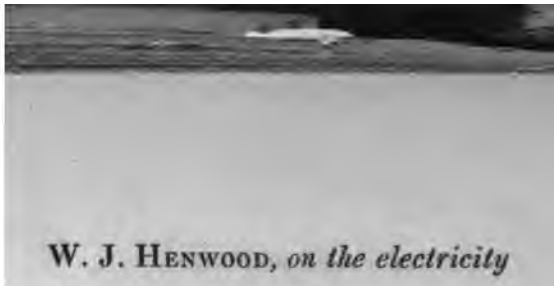
(C.) *The directions and quantities of electricity observed in rocks and veins, when plates of different metals are employed.*—

Soon after the announcement of Mr. R. W. Fox's discovery of electric currents in the metallic portions of certain *lodes,* Mr. Christie remarked[3] that some

[1] Dr. Faraday, *Experimental researches in electricity,* viii. series, p. 293 of the reprinted volume. The current from a pair of zinc and copper plates, less than an inch square, immersed in a very dilute solution of common salt, afforded almost an instantaneous result.

[2] Report of the Royal Cornwall Polytechnic Society (1841), p. 163.

[3] Reports of the British Association (1833), p. 118.



results might be due to the electric prop
apparatus employed; an objection whic
ccurred to M. Becquerel.[1] Mr. Taylo
[2] that the currents were produced by che
es induced by atmospheric influences o
and M. Von Strombeck seems to have
a somewhat similar opinion.[3]

order to obviate these objections, Mr. H
nstituted a series of experiments on the c
t *Wheal Jewel*, in which he effected the
ation between the *lode* and the galvanor
mes with copper, sometimes with zinc p
ccasionally with one of each. His r
he same, whether the plates were of simi
erent metals.[4]

fessor Reich has also sometimes used
of copper, but occasionally he substitu

the rocks near them: in some cases two plates of copper, in others two of zinc, and occasionally one plate of each, were used;—the positions, also, of the plates were at times reversed.[1]

Columns 2 and 4 of the following tables (II. and III.) denote the localities particularized by the same letters in column 4 of Table I.; and the letters *c* and *z*, in columns 3 and 5, point out whether a *copper* or a *zinc* plate was applied: the sixth column indicates the directions of the currents, and the last the amount of their action on the galvanometer.

The mineral compositions of all the points subjected to trial are particularized in Table I.

[1] The metallic plates used in these experiments were about 6 inches long and 3½ inches wide.

TABLE II.

Experiments on the electricity of the *Caunter lode*, and of the rocks, at *Longclose (East Wheal Crofty)*.

No.	South station.	Eastern plate.	North station.	Western plate.	Direction of current.	Deflection.
1	*a*	*c*	*z*	*c*	S.E. to N.W.	Needle revolved.
2	*b*	*c*	*z*	*c*	,,	,,
3	*c*	*c*	*z*	*c*	,,	,,
4	*a*	*z*	*z*	*c*	,,	,,
5	*b*	*z*	*z*	*c*	,,	Needle revolved rapidly.
6	*c*	*z*	*z*	*c*	,,	,,
7	*b*	*c*	*y*	*c*	,,	Needle revolved slowly.
8	*b*	*z*	*y*	*z*	,,	Needle revolved.
9	*b*	*z*	*z*	*z*	,,	Needle revolved rapidly.
10	*a*	*z*	*z*	*z*	,,	,,
11	*a*	*c*	*z*	*z*	,,	Needle revolved slowly.
12	*c*	*z*	*z*	*z*	,,	Needle revolved rapidly.
13	*b*	*c*	*z*	*z*	,,	,,
14	B	*c*	*z*	*z*	,,	Needle deflected 10°.
15	B	*z*	*z*	*z*	,,	Needle revolved slowly.
16	B	*c*	*z*	*c*	,,	Needle deflected 10°.
17	B	*z*	*z*	*c*	,,	Needle revolved slowly.
18	B	*z*	A	*c*	,,	,,
19	B	*c*	A	*c*	,,	Needle deflected 10°.
20	B	*c*	A	*z*	,,	,, 5°.
21	B	*z*	A	*z*	,,	Needle revolved very slowly
22	C	*c*	B	*c*	N.W. to S.E.	Needle deflected 2°.
23	C	*z*	B	*c*	S.E. to N.W.	,, 30°.
24	C	*z*	B	*z*	N.W. to S.E.	Needle revolved.
25	C	*c*	B	*z*	,,	Needle deflected 60°.

TABLE III.

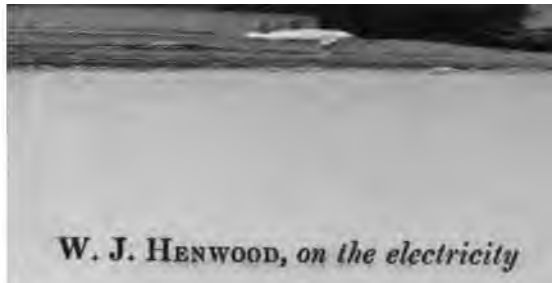
Experiments on the electricity of the *south branch*, and of the rocks, at *Rosewall Hill*.

No.	North station.	Eastern plate.	South station.	Western plate.	Direction of current.	Deflection.
1	*b*	*c*	*a*	*c*	N.E. to S.W.	Needle revolved.
2	*b*	*z*	*a*	*c*	,,	Needle revolved rapidly.
3	*b*	*z*	*a*	*z*	,,	Needle deflected 30°.
4	*b*	*c*	*a*	*z*	S.W. to N.E.	Needle revolved.
5	*b*	*c*	*c*	*z*	N.E. to S.W.	Needle deflected 20°.
6	*b*	*c*	*c*	*c*	,,	Needle revolved slowly.
7	*b*	*z*	*c*	*c*	,,	Needle revolved rapidly.
8	*b*	*z*	*c*	*z*	,,	Needle deflected 80°.
9	*c*	*z*	*a*	*z*	,,	,, 40°.
10	*c*	*z*	*a*	*c*	,,	,, 58°.
11	*c*	*c*	*a*	*c*	,,	,, 1°.
12	*c*	*c*	*d*	*c*	,,	,, 2°.
13	*c*	*z*	*d*	*c*	,,	,, 50°.
14	*c*	*z*	*d*	*z*	S.W. to N.E.	,, 120°.
15	*c*	*c*	*d*	*z*	,,	,, 55°.

(I.) At *East Wheal Crofty*, whether the plates were of copper or zinc,—of similar or of different metals,—and whether the portions of the *lode* which were connected were earthy or metallic, the directions of the currents were the same;—from S.E. to N.W. The quantity of electricity seemed to be greater when zinc (8, 9, 10, 12) than when copper plates were employed (1, 2, 3, 7). It also appeared greater when the plates were so arranged that any voltaic current they might have produced would have had the same directions as the natural electric currents (4, 5, 6), than when opposed (11, 13).

(1.) At *Rosewall Hill* the directions of the currents were the same (from N.E. to S.W.), whether both plates were of copper (1), or of zinc (3); and, also, when the zinc plate was on the north-eastern, and the copper on the south-western, station (2). When, however, the positions of these plates of dissimilar metals were reversed, so that any voltaic action between them would flow in an opposite direction to the electricity in the *lode*, the direction of the current through the galvanometer was also reversed (4). Here, however, the quantity of electricity seemed larger when plates of copper (1), than when plates of zinc (3), were employed.

(II.) *When metallic points were connected with non-metallic ones*, at *East Wheal Crofty*, the *direction* of the electricity was still from S.E. to N.W., although the plates or their arrangements might be changed; but it always flowed towards the non-metallic points. When both plates were of copper



he deflection of the needle was 10° ; wh
revolved when both were of zinc (15).
the north-west plate on the *lode* was o
he south-east one on the rock was of
he deflection was 10° ; but, when the po
plates were reversed, the needle slo
(17).[1]

At *Rosewall Hill*, also, when the roc
ere connected, no alteration in the nat
n of the plates caused any difference
on of the electricity, which was from N
When both plates were of copper, the
one case (11) but just perceptible, b
r (6) the needle slowly revolved : on the
when both plates were of zinc, the defl
one case (8) 80°, and in another (9)
fference was again in favor of the zinc

(III.) *When two portions of rock were connected,* at *East Wheal Crofty,* whether the plates were both of copper (22) or both of zinc (24), and also when the north-western plate was of zinc and the south-eastern one of copper (25), the currents were in the same direction, viz., from N.W. to S.E.; and, therefore, contrary to those flowing through the *lodes* themselves, or those flowing between the *lodes* and rocks; this direction, however, was from the colder towards the warmer points.

In the remaining case (23), the current flowed from the warmer towards the colder point;—from the zinc towards the copper plate;[1]—from S.E. to N.W.

In two of the first three experiments the needle was deflected 2°—(22), 60°—(25), and in the other (24) it revolved: in the fourth example (23) it was deflected 30°.

(1.) At *Rosewall Hill* there were four experiments, and the currents flowed in either direction

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[1] At *East Wheal Crofty,* in the summer of 1834, during a severe thunder-storm, a flash of lightning struck the iron wire *(knocker line)* by which signals are made to the surface by the workmen underground. One of the labourers, who at a depth of about 70 fathoms was at the same instant in the act of making a signal, received a shock which rendered him insensible for a short time. Shortly after this occurrence I received from the sufferer, who was acquainted with the effects of an electrical machine, a full and satisfactory relation of the particulars of this accident, which was the only injury sustained in the mine.

M. Daubuisson (Des Mines de Freiberg, iii. p. 150) describes a similar circumstance which took place in the mine *Beschert Glück,* in the year 1787.

Mr. Buddle, also, states (Parliamentary Report, on accidents in mines (1835), p. 151) that on one occasion his father saw the lightning descend by the pumps into a mine, making a loud noise, but causing no injury; and he himself witnessed a terrific explosion produced by the electric fluid, which ignited the inflammable gas ascending from the Lawson pit.

in an equal number. When both plates were of copper (12) the direction was the same as in the *lode*,—from N.E. to S.W., and the deflection was 2°; when both were of zinc (14) the current had an opposite direction, and the needle oscillated through an arc of 120°, but did not revolve. When a zinc plate occupied the north-eastern station, and a copper one the south-western (13), the current flowed in the same direction as in the *lode*,—from N.E. to S.W., and the needle was deflected 50°: on reversing the positions of the plates the direction of the current was changed (15), and the deflection was 55°. In both cases, therefore, the currents flowed from the zinc towards the copper plates.

Throughout this volume it has been my constant aim to present descriptions and arrangements of the facts which have come under my notice; and to avoid speculation on their causes. I do not intend to depart from this rule in the present instance,—indeed its observance seems to be imperative; for in dealing with substances so variable in their mineral compositions,[1] differing so greatly in their temperatures, and whose other characters are so numerous and diversified,[2] it need excite no surprize if at the

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[1] Mr. Prideaux, London and Edin. Phil. Mag., iii. (1833), p. 272.

[2] Mr. R. W. Fox found that the quantity of foreign matter in water from the mines did not generally exceed 5 or 6 grains in a pint; though in one instance it was 92 grains:—it chiefly consisted of muriatic and sulphuric salts.

Cornwall Geo. Trans., iii. p. 323.

Small as these quantities of salts are, mine-water is well known to be a powerful preservative of wood from dry rot. The late Captain Hercules Michell suggested the formation of a tank for receiving the water from the great Gwennap adit, and immersing in it the timber intended for ship-building.

commencement of our enquiries we are unable to determine those general laws, the discovery of which is always reserved as the last reward of diligent and patient research.

The experiments of M. Becquerel,[1] Mr. R. W. Fox,[2] Mr. Crosse,[3] and others, on the chemical changes in various substances by the long-continued action of electricity of low tension, are, without doubt, more or less connected with our present subject. They are, however, separated from it by an interval of unknown extent, unexplored by experiments;[4]—and if we abandon the cautious process of

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1 Traité de l'Electricité, i. p. 330, iii. p. 295

2 Reports of the British Assoc. (1836), p. 81: Report of the Royal Cornwall Polytechnic Society (1836), p. 115.

3 Reports of the British Association (1836), p. 47.

4 On the 17th of February, 1842, an earthquake shock was felt throughout considerable portions of the Helston, Camborne, and Redruth mining districts. Noises were heard, and concussions felt, both at the surface and at considerable depths in several of the mines.

The sounds heard at the surface were compared to distant thunder, and the passing of carriages;—underground, to the falling of the bucket *(kibble)* down the shaft, followed in some instances by *a rattling as of a chain descending*,—to the falling of rubbish *(running of stulls)*, and in one instance the rock emitted a sharp crackling noise.

Houses shook so that earthenware clattered on the shelves,—hedges were felt to tremble, as also were some portions of the workings in the mines; and in one instance (at *East Wheal Crofty*) the men left their work in alarm, fearing that the sides of the shaft, in which they were, was falling. Report of the Royal Institution of Cornwall (1841, published in 1842), p. 44: Report of the Royal Cornwall Polytechnic Society (1841), p. 167.

Mr. Moore states that the earthquake-shock, in the present year, was so severely felt in some of the coal mines in Lancashire, as to have terrified the labourers; and that the boring of a well, near Bolton, was so dislocated that the rods would not pass,—a spring also which had flowed there had entirely disappeared. *Standard*, 1843, April 19th.

ion, and attempt to supply our want
with vague and hazardous conje
etard, rather than advance, our p
covery of truth.

W. J. HENW

RENCE-STREET, PENZANCE,
1843, APRIL $\frac{10\text{th},}{11\text{th}.}$

APPENDIX.

No. 4.

Statistical notices of the Mines in Cornwall and Devon.

As the foregoing pages contain so many details of the descriptive and economic geology of the mining districts of the Duchy of Cornwall, it may be useful to add a brief notice of their mineral produce,—of the population employed,—machinery required,—and materials consumed in them.

In "*Grylls's Mining sheets*"[1] the yearly produce of tin and copper ore is accurately stated; and their quantities and value during many years are given in great detail by Sir Charles Lemon, Bart.,[2] and Joseph Carne, Esq.[3]

Of the other minerals, the produce of which is less easily ascertained, the best account is by Mr. Courtney;[4] and some useful information will be found in Sir Henry Thomas De la Beche's "*Report*," pp. 609-618.

I have satisfied myself of the general accuracy of Sir Charles Lemon's statement[2] of the population

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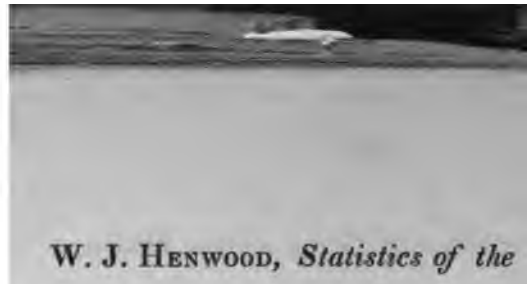
[1] Printed and sold by Francis Symons, Redruth.

[2] Journal of the Statistical Society, i. (1838), pp. 70-78. [3] Ibid, ii. p. 261.

[4] Treatise on the Statistics of Cornwall, Report of Royal Corn. Polytechnic Society (1838), p. 81.



yed in the mines, and made much u
ew instances, however, I have had occ
from Mr. Courtney's "*Statistical ren
Just,*"[1]—from the Rev. Dr. Buller's "*St
t*" of the same parish,[2]—and fron
in Register,*"[3] published by the Rev
s.

information respecting the steam po
l is chiefly derived from Messrs. Lean'
*statement of the improvements in
engines,*" pp. 143–145,—from their "
ter,*"—from Mr. Tonkin's "*Account
performed by steam-engines,*"[4]—and i
ces from my own personal enquiries.

Charles Lemon has given[5] a copiou
als consumed in the mines, from whicl
quoted: the remaining details ha

As Sir Charles Lemon's labours have supplied so full a description of the state of the mines in the year 1837–8, I have thought it better to give such additions to that account as were in my power, than to attempt a similar one for a more recent period.

The following table affords a view of the produce of the copper mines; and of the persons at work, and steam and water employed, in all the mines in the Duchy generally, during the year ending with June, 1838.

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores, and working stamping-mills.			Water-wheels.	
			Men.	Women.	Children.	Total.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
THE ST. IVES DISTRICT.		£												
Ding Dong	..	..	..	..	..	..	30·	6·	6·	12·	4·5	4·5		
							21·5	5·	4·	15·	5·	5·		
Morvah and Zennor Mines	..	..	86	2	28	116	40·	8·	7·					
Saint Ives Consols	..	..	237	16	60	313	50·	..	..	20·	4·	4·		
										20·	4·	4·		
										20·	4·	4·		
Wheal Trenwith.....	476	4,457	83	6	20	109	30·	8·	7·	18·	4·	4·		
Balnoon	..	..	62	6	12	80	30·	8·	7·	20·	4·	4·		
Wheal Reeth	..	..	147	18	66	231	36·	7·5	7·5	20·	5·7	5·7		
										20·	4·	4·		
										20·	4·	4·		
										15·	4·	4·		
Wheal Mary	..	..	118	14	31	163	20·	6·	6·	14·5	3·7	3·7		
South Wheal Mary.....	..	..	11	..	3	14								
Tincroft Consols	..	..	33	..	4	37	20·							
Providence Mines	777	6,576	83	19	30	132	30·	6·	6·					
West Poldice	..	..	..	..	..	30	56·	9·	5·5					
Baldue	..	..	5	..	1	6								
Gurnett's Head	..	..	24	..	..	24	..	..	..	..	..	..	30·	3·5
Lelant Consols	..	..	20	..	..	20								
Wheal Sarah	..	..	12	..	..	12	..	..	..	..	..	..	20·	2·

Children.		Total.	engines pumping water.				stamping-mills.						Width in breast. Feet.
			Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.		Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.		Diameter. Feet.		
5	16												
..	6												
20	136		36·	8·	6·						50·		5.
..	70		63·	8·	6·5								
6	52		45·	8·	6·								
27	207		85·	10·	8·								
11	115		75·	9·	7·5								
6	80		80·	9·7	7·7								
6	72		70·	9·7	7·7								
3	16		70·	10·	7·5								
3	27		..	..	..						38·5		7·9
..	10		36·	7·8	5·7								
			36·	9·2	6·6								
..	4												
91	392		30·	9·	7·								
			60·	10·	8·								
52	317		80·	10·	8·								
			60·	9·	8·								
96	401		19·	6·5	6·5		18·	4.	4·				
..	10												

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores, and working stamping-mills.			Water-wheels.	
			Men.	Women.	Children.	Total.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
THE GWINEAR DISTRICT.		£												
Wheal Providence	741	6,055	61	8	24	93	36·	9·	7·					
Trevaskus	274	1,928	103	30	11	144	60·	10·5	8·5					
Wheal Fancy	..	..	8	..	..	8								
Binner Downs.....	2,704	13,605	250	100	40	390	70· 50· 42· 24·	10· 9·6 9· 5·2	7·5 8·0 7·5 5·2	19· 19·	4·5 4·5	4·5 3·5		
Relistian	2,435	16,405	138	67	45	250	60·	9·	7·5	22· 22·	5· 5·	5· 5·		
Wheal Julia	1,061	6,166	100	26	22	148	80·	11·	9·	10· 12·	4· 3·5	4· 3·5		
Godolphin	1,602	11,963	370	70	40	480	80· 80·	10· 10·	8· 8·					
THE HELSTON DISTRICT.														
Great Work.....	207	2,033	298	46	74	418	60· 60·	9· 8·	7· 7·	15·	3·5	3·5		
Wheal Vor	62	391	592	327	255	1,174	80· 80· 53· 45· 24· 48·	10· 10· 9· 6·8 6· 9·	8· 7·5 7·5 5·6 6· 7·	24· 27· 16·5 24· 16· 14· 18· 18· 16· 16·	6·5 5· 5· 5· 3·5 4· 4· 4· 4· 4·	6·5 5· 5· 5· 3·5 4· 4· 4· 4· 4·		

Children.	Total.	Engines pumping water.			stamping-mills.					
		Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
17	161	45·	9·	7·5	18·				
..	121	48·	9·	6·				14·	7.
..	60	..	..	..	..	..	..		
..	30	36·	9·	6·					
..	60	42·	8·	5·7					
..	130	60·	9·	7·	18·	5.	5·		
6	52	40·	8·	7·					
..	4								
..	..	36·	8·	8·					
..	..	30·	7·	7·					
..	..	80·	11·	9·					
8	72	45·	8·	7·					
1	5								
22	189	60·	8·	5·5	13·5	7·	7·		
					13·5	4·5	4·5		
					16·	5·	5·		
					20·	5·	5·		
70	590	76·	9·	7·5	20·	6·	6·		
					18·	4·5	4·5		

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores, and working stamping-mills.			Water-wheels.	
			Men.	Women.	Children.	Total.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
CAMBORNE DISTRICT continued.		£												
Cook's-kitchen	2,030	9,909	..	..	..	247	50·	..	..	15· 16· 24·1	.. ..	..	54· 46· 52.	2·3 2·5 3·
Tincroft	1,987	8,327	..	..	..	309	56·	9·3	7·2	36·	9·	3·5		
Cairn Brea	6,918	41,362	517	137	69	723	76.	9·	7·8	20· 18· 18·	5· 4· 4·	5· 4· 4·		
Wheal Harriette	221	402	21	8	4	33								
Wheal Agar.....	..	..	..	..	..	55	50·	9·	7·					
Camborne Consols	..	..	4	..	..	4								
West Dolcoath.....	..	..	4	..	1	5								
Wheal Rome	..	..	..	..	..	8								
Wheal Seaton	112	821	..	..	..	50	45·	6·6	5·7					
North Roskear	4,310	24,554	300	190	150	640	70· 36·	10· 8·	8· 6·	18·	4·	4·		
South Roskear.....	2,517	11,659	148	172	60	380	60· 30·	9· 8·	7· 6·	16· 22·	4· 5·	4· 5·		
East Wheal Crofty	8,134	40,185	456	404	144	1,004	80· 36·	10·3 8·	7·7 7·	26·	5·	5·		
East Pool.....	1,957	15,311	111	82	18	211	60·	9·7	7·7					
Glebe	..	..	2	..	..	2								
South Wheal Basset	2,039	10,994	..	..	..	230	40· 30·	7·5 7·	6·2 6·					
Wheal Tehidy	..	..	..	..	..	..	36·	9·	7·					

1 With a second cylinder 45 inches in diameter.

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores, and working stamping-mills.			Water-wheels.	
			Men.	Women.	Children.	Total.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
THE REDRUTH DISTRICT.		£												
Wheal Tolgus	177	955	..	..	..	..	70· 70· 25·5	10· 10· 6·	7·5 7·5 6·	20· 18·	4· 4·	4· 4·		
Wheal Buller	1,983	11,876	83	42	30	155	36· 36·	7·7 8·	6· 6·					
Tresavean	12,303	76,272	..	..	..	1,354	60· 60·	7·7 8·7	6· 7·2	20· 20· 20·	4· 4· 4·	4· 4· 4·		
Trethellan	591	2,324	..	..	..	77								
Wheal Damsel	253	1,449	28	1	11	40	50·	9·3	7·2	20·	4·	4·		
Wheal Jewel	3,317	20,701	212	53	94	359	39·	8·5	6·	20·	4·	4·		
West Wheal Jewel	198	701	79	10	35	124	36·	8·	7·					
Wheal Gorland	498	3,574	53	12	21	86								
Wheal Unity Wood	3,204	17,420	206	80	138	424	80·	10·	7·5	20·	4·	4·		
Poldice	815	4,989	..	..	..	..	90·	10·	7·	20· 20·	4· 4·	4· 4·		
Carharrack, &c.	1,152	5,003	57	45	31	133								
North Downs	..	..	16	3	5	24								
Wheal Harmony, &c.	490	3,693	..	..	..	..	70· 40·	9·2 8·	7· 6·					
Wheal Mary and Wheal Parent	..	..	..	..	..	30	45·	7·	7·					
Hallenbeagle	1,104	5,010	122	20	50	192	36· 70·	7·7 10·	6· 8·					
Wheal Uny	..	..	..	..	..	146	70·	10·1	8·					

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores, and working stamping-mills.			Water-wheels.	
			Men.	Women.	Children.	Total.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
REDRUTH DISTRICT continued.		£												
Wheal Andrew	..	..	7	..	2	9								
Wheal Busy.....	669	1,802	34	50	28	112								
Wheal Amelia.....	..	..	4	..	..	4								
Bell	..	..	6	..	..	6								
Wheal Clinton.....	..	..	4	..	1	5								
Creegbraws	..	..	26	5	10	41								
East Downs.....	..	..	6	..	2	8								
North Hallenbeagle	..	..	30	6	4	40								
Wheal Vyvyan	225	982	54	25	24	103				21·	4·	4·		
							85·	10·3	7·7	20·	4·	4·		
							80·	11·3	8·7	20·	4·	4·		
							65·	9·	7·5	20·	4·	4·		
Consolidated Mines	19,459	126,211	..	..	..	..	90·	10·	7·5	24·	4·	4·		
							90·	10·	7·5	24·	4·	4·		
							65·	9·	7·5	21·	4·7	4·7		
			1,730	869	597	3,196				22·	4·	4·		
							90·	9·	8·	20·	4·	4·		
United Mines	4,359	28,544	..	..	..	..	30·	9·	7·5	20·	4·	4·		
							85·	10·3	7·5	20·	4·	4·		
							85·	10·	8·5					
Treleigh Consols.....	546	2,579	..	..	..	..	50·	9·	7·					
Cardrew Downs	306	1,643	24	6	10	40	66·	8·7	7·					
Carnon Stream.....	..	..	144	2	66	212	40·	8·	6·5					

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed. Men.	Women.	Children.	Total.	Single-acting steam-engines pumping water. Diameter of cylinder Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Steam-engines drawing ores, and working stamping-mills. Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Water-wheels. Diameter. Feet.	Width in breast. Feet.
THE ST. AGNES DISTRICT.		£												
Wheal Sparrow	134	570	31	..	..	31								
United Hills	4,010	20,691	269	90	..	359	80·	10·	8·					
							58·	8·3	6·5					
Wheal Prosper	..	..	10	..	4	14								
South Wheal Towan	1,771	9,260	..	..	..	..	40·	9·	7·					
Wheal Clifton	86	270												
Wheal Burrow	390	868	..	..	..	..	64·	8·	6·					
							58·	9·5	8·2					
Wheal Ellen	1,762	8,695	..	..	..	220	70·	10·	7·5					
Great Wheal Charlotte ..	659	2,340	..	..	..	..	60·	9·	7·					
Wheal Kitty	50	466	118	52	88	258	40·	..	..	32·	9·	8·		
Wheal Prudence.....	916	3,730	40	20	13	73	33·	8·7	6·7					
Great Saint George.....	5,774	27,097	255	35	50	340	60·	10·	6·5	20·	5·	5·		
							40·	9·	7·5	18·	4·	4·		
							70·	10·	7·5					
Wheal Leisure	1,073	3,322	68	6	21	95	70·	10·	8·	18·	4·	4·		
							66·	9·8	7·7					
Wheal Budnick	..	..	99	41	32	172	36·	8·	6·	22·	6·	6·		
Polberrow	..	..	362	34	82	478	60·	10·	8·					
Polbreen	18	198	80	..	..	80	50·	10·	8·					
Perran Consols	..	..	80	14	6	100	60·	10·	8·3					
Wheal Elizabeth	116	601												

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores, and working stamping-mills.			Water-wheels.	
			Men.	Women.	Children.	Total.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
ST. AGNES DISTRICT continued.		£												
Wheal Plenty	155	841												
Turnavoore	..	..	4	..	1	5								
North Towan	..	..	20	..	..	20								
Wheal Trevaunance	..	..	12	..	..	12								
Trebelzue	..	..	19	..	..	19								
Wheal Charles	..	..	10	..	..	10								
Wheal Clarence	..	..	10	..	..	10								
West Cliff Down	..	..	6	..	..	6								
Wheal Coit	..	..	8	4	4	16								
Friendly Mines	..	..	8	2	2	12								
Wheal Pye	..	..	3	2	1	6								
THE ST. AUSTELL DISTRICT.														
East Wheal Strawberry ..	..	..	71	19	30	120	50·	9·	7·					
Polgooth	..	..	141	10	51	202	66·	9·8	7·4	27·	5·	5·		
St. Austell Hills.....	..	..	72	13	24	109	..	..	..	30·	6·	6·		
Carclaze	..	..	8	..	6	14								
North Claze	..	..	7	1	1	9								
Rocks	..	..	74	9	12	95	40·	8·8	5·2					
Carrygian.....	..	..	30	1	4	35								
Charlestown	..	..	431	120	263	814	50·	9·3	8·2	32· 18·	9· 4·	7· 4·		

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores, and working stamping-mills.			Water-wheels.	
			Men.	Women.	Children.	Total.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
St. Austell District continued.		£												
East Wheal Basset.....	..	..	..	..	..	100	70·	8·	8·					
Wheal Change	..	..	..	..	..	40								
South Polgooth	..	..	92	14	20	126	36·							
East Crennis	1,033	7,504	124	46	62	232	76·	10·3	7·2	18·	5·	5·		
							41·	9·3	7·2	16·	4·	4·		
Pembroke	196	1,204	75	12	52	139	50·	9·	7·	18·	5·	5·		
							40·	9·	6·5					
													34·	4·5
													30·	3·5
													19·	4·
													27·	2·5
										18·	4·	4·	24·	3·
Fowey Consols[1]	15,254	85,434	1,057	308	315	1,680	80·	10·3	9·2	18·	4·	4·	24·	3·6
							24·	8·5	5·5	20·			24·	1·7
										22·			27·	6·
										22·			40·	3·5
													30·	6·
													24·	4·
													14·	2·5
													12·	1·5
Wheal Union	101	423	..	..	..	..	40·	9·	7·					
Pentuan Stream	..	..	18	..	5	23	28·	8·	6·					

TABLE I. continued.

Mines.	Copper ore. Tons of 21 cwt.	Value.	Persons employed.				Single-acting steam-engines pumping water.			Steam-engines drawing ores, and working stamping-mills.			Water-wheels.	
			Men.	Women.	Children.	Total.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.	Width in breast. Feet.
CALLINGTON DISTRICT.		£												
Holmbush	1,284	8,310	145	8	38	191	39· / 50·	7· / 9·	7· / 8·	18·	4·5	4·5		
Redmoor	..	..	110	16	25	151	50·	9·	7·					
East Cornwall	..	..	6	..	..	6								
Cornwall Great United Mines	..	..	155	20	22	197								
Wheal Brothers	..	..	2	..	..	2								
Wheal Sisters	..	..	4	..	..	4								
Wheal Barnes	..	..	22	..	..	22								
Wheal Millpool	..	..	20	..	..	20								
South Caradon	140	1,198	..	..	..	..	24·	9·	6·					
Wheal Martha	..	..	26	10	4	40								
Phœnix	..	..	13	..	1	14								
Wheal Triumph	..	..	10	..	2	12								
West Wheal Tamar	..	..	45	..	..	45								
Gunnis Lake	..	..	62	7	19	88	40·	8·	6·	15·	4·	4·		
Tamar Consols	..	..	93	17	23	133	50· / 50·	10· / 9·	8· / 7·	20· / 18·	3· / 3·	3· / 3·	40·	2·2
Wheal Franco	1,461	5,078	..	..	..	133	..	..	..	..	..	..	32· / 26· / 22· / 12· / 14· / 14·	6· / 3· / 4· / 6· / 2· / 2·

Children.	Total.	engines pumping water.				stamping-mills.					Width in breast. Feet.
		Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter of cylinder. Inches.	Stroke in cylinder. Feet.	Stroke in pumps. Feet.	Diameter. Feet.			
								51·			10·
								50·			6·3
								40·			4·3
192	453	80·	10·	7·5	..	..	..	32·			7·3
								40·			5·3
								26·			4·1
								11·			10·3
								42·			5·
								40·			4·3
8	65	..	..	..	..	..	..	40·			4·
								27·			3·2
								14·			4·5
8	27										
14	117	..	..	..	..	..	..	40·			5·
								40·			4·5
								32·			2·7

The foregoing table shows that the copper ore produced from the mines in Cornwall and Devon, within the year ending with June, 1838, was 151,554 tons, averaging $7\frac{7}{8}$ per cent of metal, and therefore containing 12,042 tons of copper. The average price of the ore was £5 : 18 : 4 per ton, and the Standard value of copper £109 : 3 : 0 per ton; giving a total value of £897,558 : 0 : 0.[1]

The quantity of tin obtained during the same time was about 5,130 tons;[2] and, as the mean per centage of metal in the ore was $65\frac{5}{8}$ (or $13\frac{1}{8}$ in 20),[3] it was yielded by about 7,817 tons of ore. The average price of tin during the year was about £90 per ton, making a total value of £461,700.

Mr. Taylor states the quantity of lead produced within the district to have been,—

In 1828	2,000 tons,[4]	
1835	140 „	[5]
Sir H. T. De la Beche estimated it,		
in 1838, at	180 „	[6]
Mr. Courtney „ „ ..	1,800 „	[7]

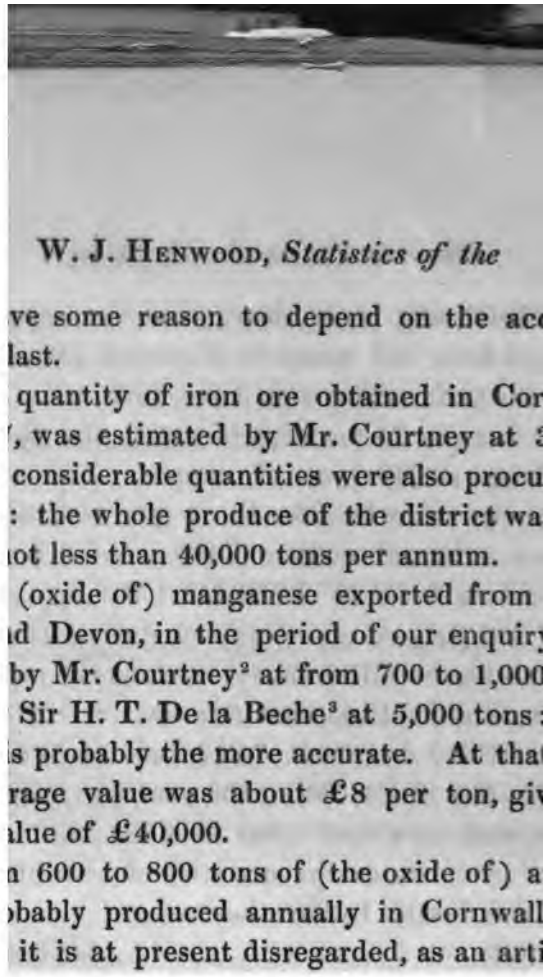
[1] The quantities of copper ore obtained at various periods are particularized by Mr. Pryce, Mineral. Cornub., p. xi.; in the Corn. Geo. Trans., i.-ii.-iii.-iv.; by Mr. Taylor, Records of Mining, p. 169; by Sir Charles Lemon, Journal of the Statist. Soc., i. p. 70; by Mr. Courtney, Report of Royal Corn. Pol. Soc. (1838), p. 136; and by Sir H. T. De la Beche, Report, pp. 597-608.

[2] Until Oct., 1838, all tin obtained in the Duchy of Cornwall paid a *duty* to the Duke, or to the Sovereign when there was no Duke:—that smelted in Cornwall of four shillings for 120 lbs.; that in Devon of one shilling and sixpence three farthings for 112 lbs. The weighing, necessary for ascertaining the amount of *duty*, supplied a record of the quantity, and since its abolition there is no means of discovering it with any degree of certainty.

[3] For this information I am indebted to Thomas S. Bolitho, Esq., who also mentions that the proportion of metal in the ore has not varied more than 1 per cent. for several years past.

[4] Records of Mining, p. 173. [5] Mining Review, No. ix. (1837), p. 36.

[6] Report, p. 611. [7] Report of the Royal Corn. Polytech. Soc. (1838), p. 100.



W. J. Henwood, *Statistics of the*

ve some reason to depend on the ac
last.

quantity of iron ore obtained in Cor
', was estimated by Mr. Courtney at
considerable quantities were also procu
: the whole produce of the district wa
ıot less than 40,000 tons per annum.

(oxide of) manganese exported from
ıd Devon, in the period of our enquir
by Mr. Courtney[2] at from 700 to 1,000
Sir H. T. De la Beche[3] at 5,000 tons
ıs probably the more accurate. At tha
rage value was about £8 per ton, giv
ılue of £40,000.

n 600 to 800 tons of (the oxide of) a
›bably produced annually in Cornwall
it is at present disregarded, as an arti

Blende *(black jack)* and iron pyrites *(mundic)* have recently been worked to considerable extent, and several thousand tons of each have been exported; during the year 1837-8, however, they were unwrought.

The population enumerated in the foregoing table amounts to 28,522: but there are several mines,[1] of which we have no account, which employed, at least, 1,500 persons more: the total number of individuals labouring in the mines, in the year 1837-8, was, therefore, not less than 30,000.

I have not, in every instance, been able to obtain an exact account of the numbers of men, women, and children employed; but, as the cases in which I have procured every particular consist of mines in all the different districts, and comprize more than six-sevenths of the whole, I have some confidence in the accuracy of the proportions they indicate. In the mines particularized in the preceding table the men employed were 14,905,—the women 4,650,—and the children 4,650.

If we apply these proportions to the total number, it will give,—

Men	18,472
Women	5,764
Children	5,764
	30,000

[1] *Ding Dong, Wheal Leeds, Sydney Cove, Duffield, Wheal Tehidy, Wheal Tolgus, Wheal Harmony, Poldice, Treleigh Consols, Wheal Sparrow, South Wheal Towan, Wheal Burrow, Wheal Clifton, Wheal Plenty, Great Wheal Charlotte, Wheal Elizabeth, Wheal Union, South Caradon,* &c.

average monthly wages of men du
was about £2 : 12 : 6,[1] and of wo
n about 14*s.* 6*d.*,[2] which gives a total
000 for labour alone.

mechanical powers employed on th
time, were—

Steam-engines.

ameter of Cylinder. Inches.	*Pumping water.*	*Working raising*
eeding 20·	7·	.....
20· to 30·	21·	.....
30· ,, 40·	33·	.....
40· ,, 50·	25·	
50· ,, 60·	21·	
60· ,, 70·	20·	
70· ,, 80·	18·	
80· and above	8·	
	153·[3]	

Water-wheels.

Diameter not exceeding 20· feet	1
20· to 30· ,, ...	1

The quantities and prices of the principal materials consumed in the mines, in the year 1837, have been ascertained by Sir Charles Lemon:[1]—they were—

Coals	56,860 tons,	@ £0 : 17 : 0 ℔ ton ..	£48,331
Timber	14,056 loads[2] ,,	2 : 12 : 0 ,, load ..	36,545
Gunpowder ..	300 tons, ,,	44 : 0 : 0 ,, ton ..	13,200
Candles	1,344,000 lbs.[3]	.....	35,000

Although the foregoing particulars are probably close approximations to the truth, they cannot pretend to minute or perfect accuracy; as the produce of the mines,—the population employed,—and the materials consumed in them, are subject to continual fluctuation.[4]

---

[1] Journal of the Statistical Society, i. (1838), pp. 81-82.

Sir Charles Lemon also gives the following account of the different materials used in the *Consolidated* and *Fowey Consols Mines* in 1836; which will aid us in obtaining an approximation to the total quantity of each article consumed in all the mines of Cornwall and Devon:—

	Consolidated Mines.	*Fowey Consols.*
Coals, tons	11,817	1,301
Iron ,,	108	90
Steel, cwts.	135	91
Tallow ,,	375	77
Ropes ,,	977	379
Candles .. lbs.	113,916	72,000
Gunpowder .... ,,	64,000	66,500
192 hides of Leather ,,	8,996	2,352
Norway Timber, cubic feet	49,091	45,928
American Pine ,,	2,129	1,376
,, Oak ,,	—	703
Patent half-inch chain, fms.	2,474	700
Pick and Shovel Hilts, doz.	13,098	664
Nails, &c., bags	91	53
Engine Shag (flannel), yds.	3,438	700
Oil, galls.	996	916
Safety-fuse for blasting	£ 269 : 10 : 0	£ 475 : 4 : 2
Foundry bills, Pumps, &c.	£1,735 : 0 : 1	£1,775 : 4 : 2
Books, Stationery, &c.	£ 50 : 6 : 7	£ 52 : 5 : 4

Ibid, p. 76.

[2] Of 50 cubic feet.

[3] This estimate I have obtained through the kindness of Mr. Higgs.

[4] Full details of the produce,—population and machinery employed,—and coals consumed, in the mines between Chacewater and Camborne, in the years 1817 and 1818, are given in Mr. Thomas's Report, p. 75.

W. J. HENWOOD, *Statistics of the M*

, steel, tallow, leather, and ropes ar
tant items in mining expenditure;
uantity of these I have been unabl
nts, or even estimates, entitled to
e.

W. J. HEN

ARENCE-STREET, PENZANCE,
1843, MARCH 30th.

EXPLANATION OF THE PLATES.

In the *plans* the *lodes* are denoted by single lines, and the *cross-veins* by double lines; whilst *elvan-courses* and masses of granite are shaded.

In the figures, illustrative of the *electrical experiments*, the *workings* are denoted by double lines, and arrows indicate the directions of the currents.

In *longitudinal sections*, only the portions which have been removed are shaded.

All those marked with an asterisk (*) were copied from the working plans and sections on the mines:—the others, with the assistance of the Agents of the mines, were constructed from my own observations.

Plate I.

Fig. 1. Imaginary illustration of a *lode heaved* towards the right hand and greater angle.
,, 2. Imaginary illustration of a *lode heaved* towards the left hand, and smaller angle.
,, 3. Plan of *Wheal Bellon*, Table II.
,, 4. ,, *Park-noweth*, Table VI.
,, 5. ,, *Botallack*, Table VII.
,, 6. Electrical experiment at *Botallack* (longitudinal section).
,, 7. Plan of *Wheal Cock*, Table VIII.
,, 8. Electrical experiment at *Wheal Cock* ,,
,, 9*. Longitudinal section of *Levant*, Table IX.
,, 10. Electrical experiment at *Levant* ,,

Plate II.

Fig. 1*. Plan of *Wheal Spearn*, Table X.
,, 2*. ,, *South Spearn*.
,, 3*. ,, *Ding Dong*, Table XIII.
,, 4*. ,, *Saint Ives Consols*, Table XVI.
,, 5*. Longitudinal section of the *Carbona* at *Saint Ives Consols*.
,, 7*. Plan of *Wheal Speed*, Table XXII.

Plate VII.

Fig. 1*. Plan of *Wheal Buller*, Table LVIII.
„ 2*. „ *Tresavean*, Table LIX.
„ 3. „ *Ting Tang*, Table LX.
„ 4*. „ *East Wheal Damsel*, Table LXIV.
„ 5. Electrical experiment at *Wheal Damsel* (lon. sect.).
„ 6. Electrical experiments „ (transverse section).
„ 7*. Plan of *Wheal Jewel*, Table LXV.
„ 8. Electrical experiment at *Wheal Jewel* (transverse sect.).
„ 11*. Plan of *Wheal Unity Wood*, Table LXVI.
„ 12*. „ *Cardrew Downs*, Table LXVIII.
„ 13*. „ *North Downs*, Table LXIX.
„ 14. „ a part of *North Downs*.
„ 15. Transverse sect. of *South Wheal Towan*, Tab. LXXII.
„ 15*a*. Electrical experiment at „ (lon. sect.).
„ 16. Plan of part of *Wheal Towan*, Table LXXIII.
„ 17. Electrical experiment at „ (longitudinal section).

Plate VIII.

Fig. 1*. Plan of the *Consolidated Mines*, Tables LXII. LXIII.
„ 2, 3. Electrical experiments at the *Consolidated Mines*, (longitudinal sections).
„ 4*. Plan of the *United Mines*, Table LXI.
„ 6. Transverse section of *Wheal Vyvyan*.

Plate IX.

Fig. 1. Transverse section of *Polberrow*, Table LXXVII.
„ 3*. „ *West Pink*, Table LXXVIII.
„ 5. Plan of *Wheal Prudence*, Table LXXX.
„ 6. Transverse section of *Wheal Prudence*.
„ 7*. Plan of *Great Saint George*, Table LXXXI.
„ 8. Transverse section of *Great Saint George*.
„ 9*. Plan of *Wheal Budnick*, Table LXXXIII.
„ 10*. „ *Polgooth*, Table LXXXV.
„ 11*. Transverse section of part of *Polgooth*.
„ 12*. Plan of *Pembroke*, Table LXXXVII.
„ 14*. „ *East Crennis*, Table LXXXVIII.

Plate X.

Fig. 1†. Plan of *Fowey Consolidated Mines*, Table LXXXIX.
„ 2†. Transverse section of *Fowey Consolidated Mines*.
„ 3*. Plan of *Beam*, Table XC.

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† Both these figures, and also Plates 10 and 11 in Sir H. T. De la Beche's *Report*, are reduced from lithographic plans constructed and sold by Mr. Benjamin Brokenshaw, underground Surveyor at the *Fowey Consolidated Mines*.

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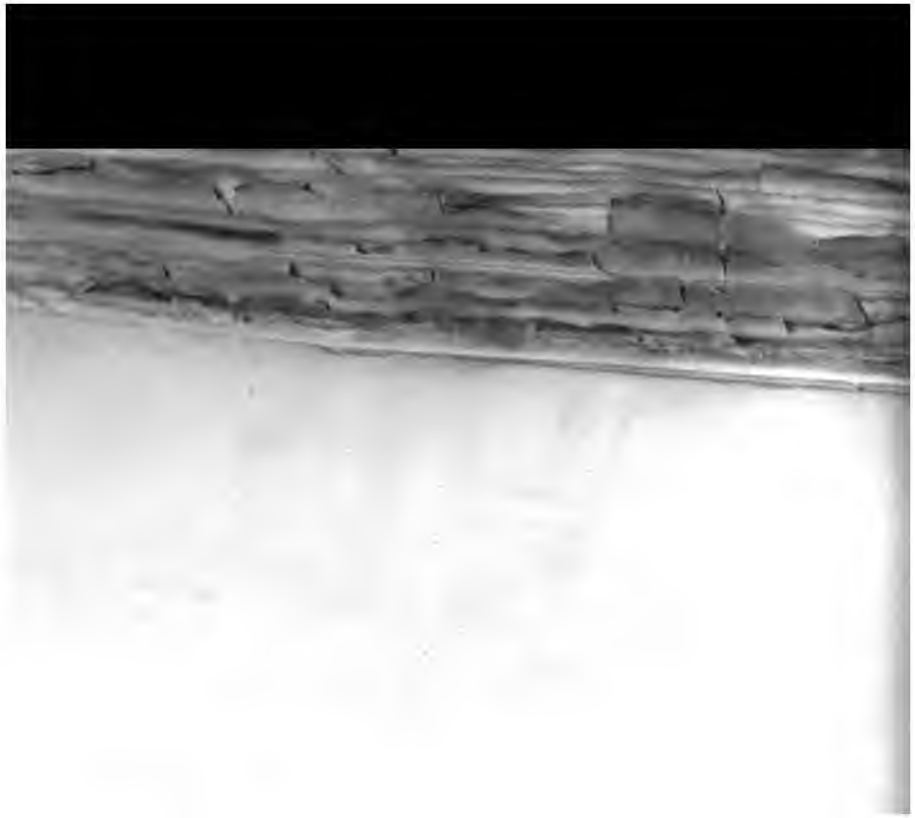
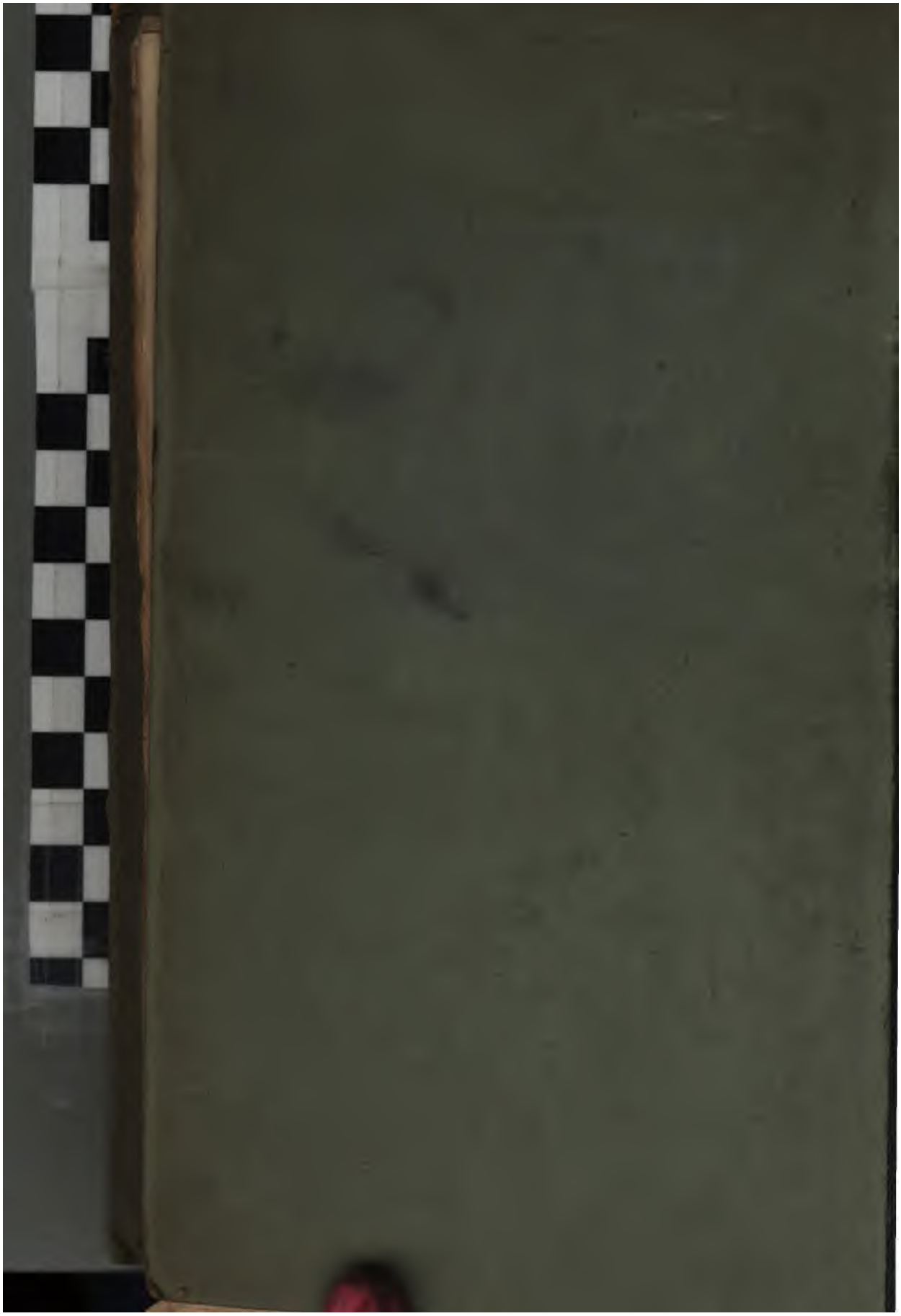
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